20.0 UPPER WILLAMETTE SPRING CHINOOK SALMON ESU

20.1 BACKGROUND

20.1.1 Description of the ESU

Upper Willamette River spring chinook are one of the most genetically distinct groups of chinook in the Columbia River Basin (Myers *et al.* 2002). Historically, passage by returning adult salmonids over Willamette Falls (RKm 37) was only possible during the winter and spring high flow periods. The early run timing of Willamette River spring chinook salmon relative to other Lower Columbia River spring run populations is viewed as an adaptation to flow conditions at the Falls. Chinook salmon begin appearing in the lower Willamette River in February, but the majority of the run ascends the Falls in April and May, with a peak in mid-May. Low flows during the summer and autumn months prevented fall run salmon from accessing the Upper Willamette River Basin. Mattson (1963) discusses the existence of a late spring run chinook salmon that ascended the falls in June. These fish were apparently much larger (25-30 lbs. (11.4-13.6 kg)) and older (presumably 6-year-olds) than the earlier part of the run. Furthermore, Mattson (1963) speculated that this portion of the run "intermingled" with the earlier-run fish on the spawning ground and did not represent a distinct run. The disappearance of the June run in the Willamette River in the 1920s and 1930s was associated with dramatic decline in water quality in the lower Willamette River.

Spring chinook populations in this ESU exhibit a life history pattern that includes traits from both ocean- and stream-type life histories. Smolt emigrations occur as young of the year and as age-1 fish in the fall and spring (Schroeder *et al.* 2004). Ocean distribution of chinook in this ESU is consistent with an ocean-type life history with the majority of chinook being caught off the coasts of British Columbia and Alaska. Spring chinook from the Willamette River have the earliest return timing of chinook stocks in the Columbia Basin with freshwater entry beginning in February. Adults return to the Willamette River primarily at ages 3 through 5 (King 2004). Historically, spawning occurred between mid-July and late October. However, the current spawn timing of hatchery and natural-origin chinook is September and early October (Schroeder *et al.* 2004).

Historically, there were five major river basins that produced spring Chinook, including the Clackamas, North Santiam, South Santiam, McKenzie, and the Middle Fork Willamette. Smaller populations also existed historically in the Molalla River and Calapooia River. The Willamette/Lower Columbia Technical Recovery Team (Myers *et al.* 2002) identified all seven of these rivers as having independent spring chinook populations historically (Table 20.1).

Table 20.1. List of natural populations identified by the Lower Columbia/Willamette TRT (Myers et al. 2002), hatchery programs in each population area, and description of the current hatchery program.

TRT Spring chinook populations	Hatchery Program (included, not included ESU)	Integrated or Isolated Program	Program description	Size of program (smolts)	Year Initiated
Clackamas	Clackamas (included ESU)	integrated	smolt	1.3 million	1979
North Santiam	N. Santiam (included ESU)	integrated	smolt	667,000	1950
South Santiam	S. Santiam (included ESU)	integrated	smolt	1.1 million	1968
McKenzie	McKenzie (included ESU)	integrated	smolt	985,000	1930
Middle Fork	Middle Fork (included ESU)	integrated	smolt	1.4 million	1957
Molalla	Non-local hatchery stock (S. Santiam)	n/a	smolt	100,000	1990
Calapooia	Non-local hatchery stock (S. Santiam)	n/a	adult	No smolts. Live adults.	1990
Summary: Seven TRT natural populations; all with hatchery programs. Five hatchery stocks all included as part of the ESU. 5.5. million annual smolt production goal.					

Clackamas – The Clackamas River population consists of naturally-produced spring chinook and the Clackamas hatchery stock (ODFW stock #19). Most of the natural production of spring chinook occurs above North Fork Dam on the Clackamas River. Since 1990 the broodstock collected for this hatchery program has been from fish returning to the Clackamas hatchery trap. The hatchery stock likely resembles native Clackamas fish more than any other stock of fish in the Willamette Basin. Substantial numbers of natural-origin fish have not been incorporated into the broodstock. However, since 2000, the hatchery stock has been managed as an integrated stock (NMFS 2000). This hatchery stock was designated as part of the ESU.

Molalla – The native population of spring chinook in the Molalla River is believed to be extinct or nearly so (Myers *et al.* 2002). In recent years, smolts from the South Santiam Hatchery have been outplanted into the Molalla River. The South Santiam Hatchery stock (ODFW stock #24) was determined to be part of the ESU.

North Santiam – The North Santiam River population consists of naturally-produced spring chinook and the Marion Forks Hatchery stock (ODFW stock #21). This hatchery stock was developed from spring chinook returning to the North Santiam River and was determined to be part of the ESU.

South Santiam **–** The South Santiam River population consists of naturally-produced spring chinook and the South Santiam Hatchery stock (ODFW stock #24). This hatchery stock was developed from spring chinook returning primarily to the South Santiam River and was determined to be part of the ESU.

Calapooia **–** The native population of spring chinook in the Calapooia River is believed to be extinct or nearly so (Myers *et al.* 2002). In recent years, live adults from the South Santiam Hatchery have been outplanted into the Calapooia River. The South Santiam Hatchery stock (ODFW stock #24) was determined to be part of the ESU.

McKenzie **–** The McKenzie River population consists of naturally-produced spring chinook and the McKenzie hatchery stock (ODFW stock #23). This hatchery stock was developed from spring chinook returning primarily to the McKenzie River and was determined to be part of the ESU.

Middle Fork Willamette **–** The Middle Fork Willamette population consists of naturally-produced spring chinook and the Willamette hatchery stock (ODFW stock #22). This hatchery stock was developed from spring chinook returning to the Middle Fork Willamette River and was determined to be part of the ESU. A small run of native spring chinook also existed historically in Fall Creek, a tributary to the Middle Fork, and is also included in this population.

20.1.2 Status of the ESU

All of the rivers below were identified as historically harboring spring chinook populations by the TRT. The BRT report (2003) did not address individual VSP parameters for this ESU.

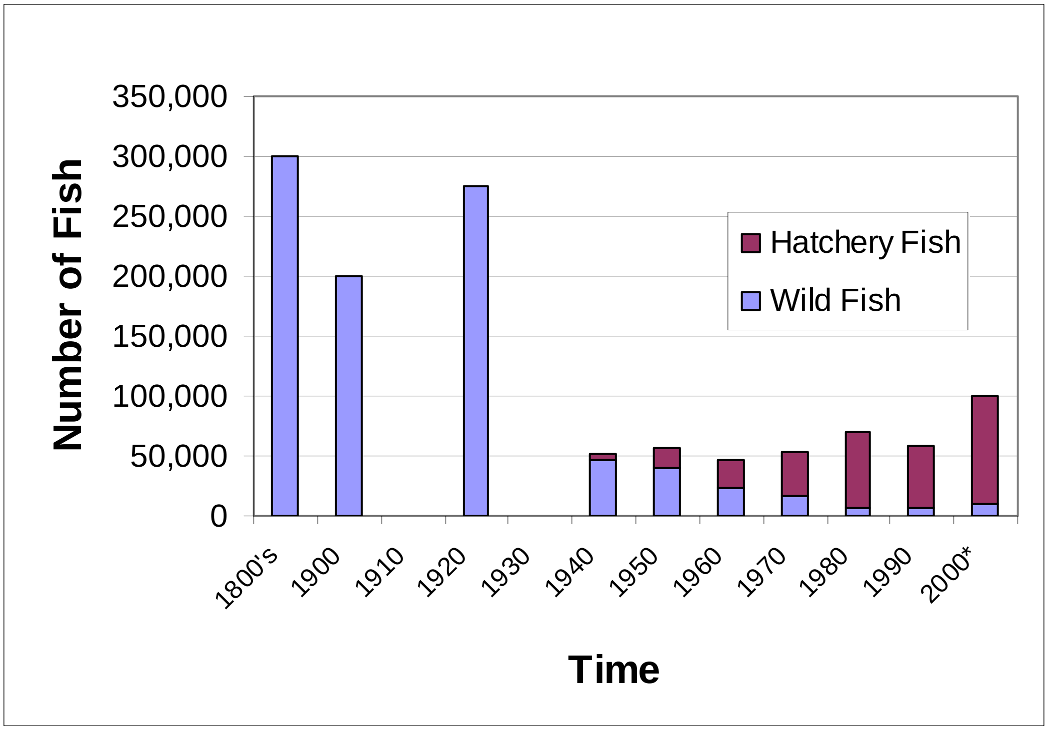

Figure 20.1. Estimated average total abundance by decade of spring chinook returning to the mouth of the Willamette River (Myers *et al.* 2002; King 2003; King 2004). * for years 2000-2004 only.

Clackamas – The Clackamas River still supports a relatively healthy run of natural-origin and hatchery-origin fish. Counts of natural-origin fish at North Fork Dam, located on the mainstem Clackamas River below the major natural production areas, numbered more than 2,200 fish in 2002 and 3,600 fish in 2003 (King 2004). The number of hatchery fish observed at the dam (which were not allowed to pass upstream) was 3,000 to 6,000 fish in 2002 and 2003.

Molalla – A small population of spring chinook existed historically in the Molalla. In recent years, few naturally-produced fish have been observed. In 2002 and 2003, less than 7% of the natural spawners were of natural-origin (Schroeder *et al.* 2003, 2004). The hatchery spring chinook released into the Molalla are from South Santiam stock. This non-local hatchery stock makes up most of the spawners present in this river. The BRT (2003) found that this population was likely extirpated, or nearly so.

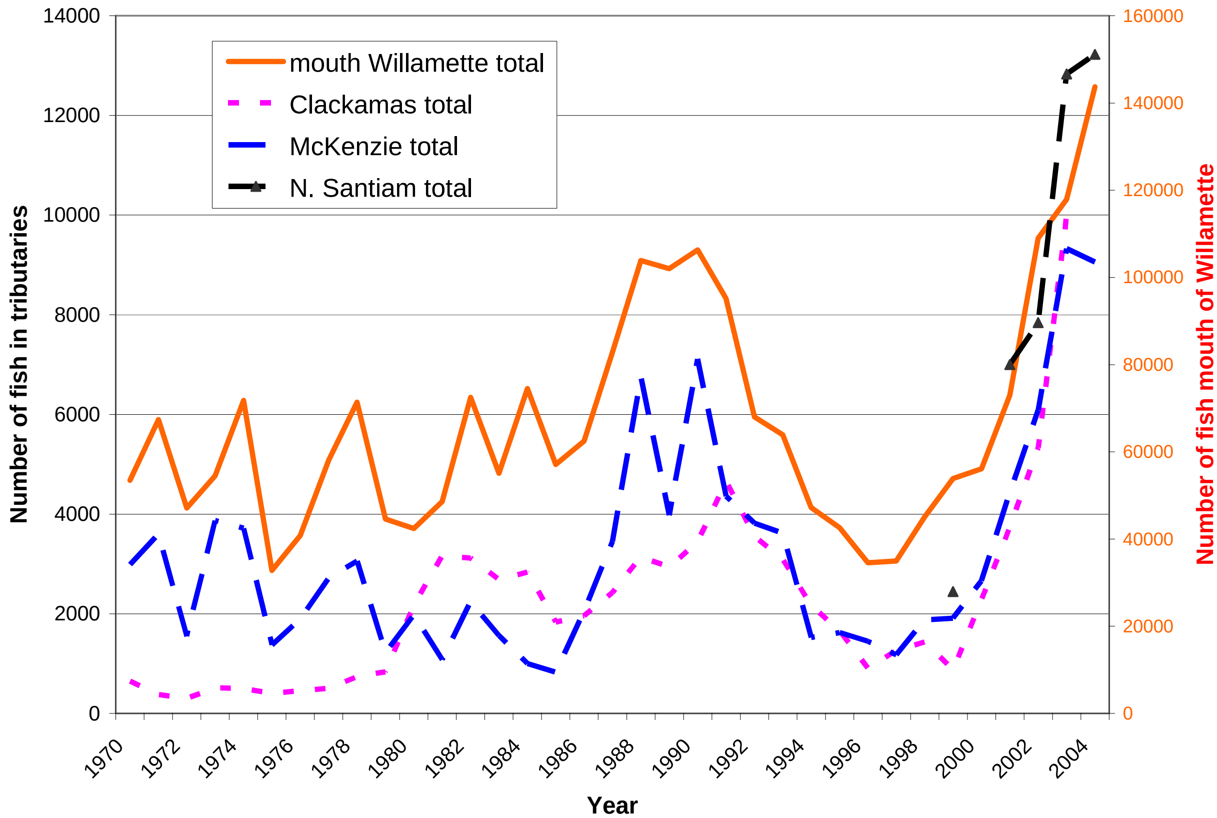

Figure 20.2. Total number of hatchery AND wild spring chinook returning to the Willamette River (right Y axis) and tributaries with counting facilities (left Y axis). Counts measured at North Fork Dam on the Clackamas, Leaburg Dam on the McKenzie, and Bennett Dams on the North Santiam. Data from King (2004).

North Santiam – The total return of spring chinook to the North Santiam River has numbered in the thousands of fish annually. However, from 2000 to 2003 (the first years when hatchery fish could be differentiated from wild fish), the average number of natural-origin fish was only 384 fish. In 2003, an estimated 681 natural-origin fish passed Bennett Dams on the lower North Santiam River compared to more than 11,000 hatchery fish (Firman *et al.* 2004). The BRT (2003) did not consider this population to be self-sustaining.

South Santiam – The estimated abundance of natural-origin fish returning to the South Santiam River in 2002 and 2003 (the only years when 100% of the hatchery fish returns could be differentiated from naturally-produced fish) was 965 and 635 adults, respectively (Firman *et al.* 2003, 2004). Even though these numbers are low, it is encouraging to see some natural production for this population. Since most of the naturally spawning fish are of hatchery-origin, it is likely that most of the naturally-produced fish are from hatchery parents. Most of these natural-origin fish were released into historic habitat above Foster Dam (impassable dam). The return of hatchery fish to the South Santiam has numbered several thousand fish annually. High densities of redds have been observed below Foster Dam in recent years. In 2003, more than 600 redds were counted below the dam. Most of the spawners are hatchery fish (Schroeder *et al.* 2004). The BRT (2003) concluded this population is not self-sustaining.

Calapooia – The Calapooia River historically supported a population of spring chinook that numbered in the range of a few hundred fish. It is believed the historic population is extinct, with limited future production potential (Myers *et al.* 2002). Recent spawning ground surveys have shown few redds, even though hatchery adult spring chinook are outplanted into the Calapooia River from South Santiam Hatchery. In 2003, even though 140 hatchery chinook were outplanted into the Calapooia River (Firman *et al.* 2004), Schroeder *et al.* (2004) observed only two redds in 7.9 miles of survey. Over 90% of the carcasses recovered were hatchery fish. The Calapooia natural spring chinook population is believed to be extirpated, or nearly so (BRT 2003).

McKenzie – The McKenzie River is only one of two rivers in the ESU where most of the historic habitat is still accessible (Clackamas River is the other river). The run of naturally-produced spring chinook in the McKenzie River is the stronghold for the ESU. Since 1994, the number of naturally-produced adults has ranged from less than 1,000 fish to more than 5,500 fish in 2003 (Figure 20.3). The returns of natural fish to the McKenzie is greater than any other river in the ESU. Returns of hatchery spring chinook to the McKenzie have also numbered in the thousands of fish annually since the early 1970s (Figure 20.8). The BRT (2003) stated it was difficult to determine if this population would be naturally self-sustaining because of the presence of naturally-spawning hatchery fish above Leaburg Dam (the area where most of the natural production occurs).

Middle Fork Willamette – Over 80% of the historic habitat for spring chinook was blocked by the construction of Dexter, Lookout Point, and Hills Creek dams in the Middle Fork basin. Since 2001, hatchery spring chinook can be distinguished from naturally-produced fish because they have an adipose fin clip. In 2002 and 2003, an estimated 987 and 147 adults, respectively, were naturally-produced spring chinook (Firman *et al.* 2004). Most of these fish were likely produced from outplants of adult hatchery fish above the dams because juvenile and adult survival below Dexter Dam is poor (Schroeder *et al.* 2002, 2003; ODFW Middle Fork HGMP 2004). The returns of hatchery spring chinook to the Middle Fork have numbered in the thousands of fish annually since the early 1970s. In 2002 and 2003, more than 6,000 hatchery spring chinook were collected at Dexter Dam. Returns of hatchery fish of this magnitude were common since 1970. The BRT (2003) did not consider this population to be self-sustaining.

The BRT (2003) considered hatchery production to be a potential risk factor to natural fish in this ESU. The BRT was concerned that hatchery fish were masking the productivity of the natural populations, interbreeding with natural fish thereby posing genetic risks, and that hatchery-origin adult returns promote fisheries that increase mortality on natural fish. The BRT concluded that most natural populations are likely extirpated, or nearly so. The only population considered potentially self-sustaining is the McKenzie. However, hatchery fish comprise a substantial proportion of the run.

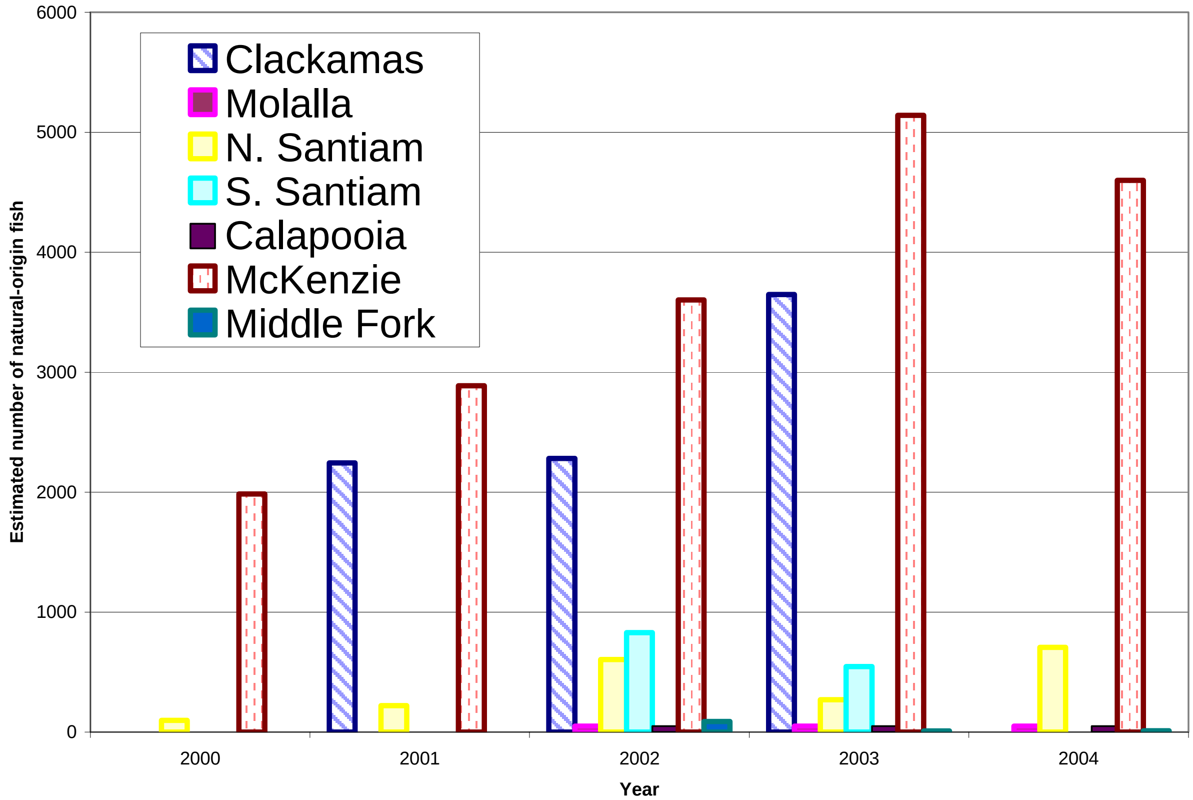

Figure 3. Estimated returns of natural origin fish to each population area. Actual number of spawners is lower in the N. Santiam, S. Santiam, McKenzie, and Middle Fork due to prespawning mortality. For these rivers, estimates are from dam counts. In the Molalla and Calapooia rivers, estimates are number of spawners.

20.2 ASSESSMENT OF THE HATCHERY PROGRAMS

All of the hatchery programs are currently using broodstocks that are integrated with the local, natural stocks. The extent to which natural-origin fish have been incorporated into the broodstocks is unknown because hatchery and natural fish could not be differentiated until recently when all hatchery fish returns were marked. The Calapooia and Molalla Rivers are the only rivers where out-of-basin fish are stocked. South Santiam Hatchery liberates juvenile and adult fish into these two rivers.

There are no natural populations in the ESU that are *not* affected to some degree by hatchery programs. Even the McKenzie River, the stronghold population for the ESU, has had substantial numbers of hatchery fish spawning naturally in recent years.

20.2.1 Clackamas

The Clackamas River currently supports a natural run of spring chinook that has averaged about 1,600 adults from 1996-2003 (Schroeder *et al.* 2004). It is important to note that this count represents a high estimate and the true number of natural fish is likely lower because some hatchery fish did not have an external fin clip during this time period. Nearly all of the natural production within this subbasin occurs upstream of North Fork Dam (Schroeder *et al.* 2002, 2003, 2004). The Clackamas River is one of two areas within the ESU with the highest return of natural-origin fish in recent years (the McKenzie is the other river).

20.2.1.1 Program History

The current Clackamas hatchery program was developed from other Willamette basin hatchery fish stocked as smolts into the Clackamas River beginning in 1976. Prior to the current program being initiated, hatchery fish were from both local returns and imports from other Willamette broodstocks (Myers *et al.* 2002). Since 1990 the broodstock for this program has been collected from fish returning to the Clackamas River.

20.2.1.2 Similarity between Hatchery-origin and Natural-origin Fish

The native spring chinook run in the Clackamas River declined substantially over the last century due to Cazadero and River Mill dams that limited migratory access to the majority of the historical spawning habitat in the basin. The run upstream of the dams was at very low levels from the 1940's until the first returns of the current program in 1980. Returns have steadily increased over the last two decades. Myers *et al.* (2002) stated the current hatchery program has significantly introgressed into, if not overwhelmed, the native population in the Clackamas River. Given hatchery and natural fish could not be differentiated from each other until recent 100% marking of hatchery releases, many hatchery fish have likely spawned naturally. The hatchery and natural-origin components of this population are likely more genetically similar to each other than other hatchery or natural fish in the ESU (Myers *et al.* 2002).

20.2.1.3 Program Design

The Clackamas spring chinook hatchery program is funded by Portland General Electric, City of Portland, and the Mitchell Act to mitigate for fishery losses caused by dams in the basin. The program is intended to provide fish for commercial and recreational harvest. Hatchery spring chinook are not purposefully allowed to spawn naturally. Hatchery spring chinook that migrate upstream to North Fork Dam are removed to the extent possible and recycled downstream through the fishery or taken to the hatchery. The management goal is to limit hatchery fish to 30% or less of the spawning population above North Fork Dam (NMFS 2000). However, in recent years nearly all of the adipose fin-clipped fish have been removed.

20.2.1.4 Program Performance

The *smolt-to-adult* survival rate of the Clackamas Hatchery stock has averaged 0.53% for brood years 1987-1996 (Figure 20.5; ODFW South Santiam HGMP 2004). The broodstock goal for the current production level is approximately 1,500 fish. Total returns of hatchery fish from this program has exceeded the broodstock goal since the late 1980s (Figure 20.4). Prior to 1990, broodstock from other rivers were used to backfill production needs due to insufficient returns back to Clackamas Hatchery. NMFS (2000) directed the comanagers to use only broodstock returning back to the Clackamas River and not use broodstock from any other sources. Funding for this program comes from mitigation agreements with Portland General Electric, City of Portland, and the Mitchell Act. The long-term funding outlook for this program is fairly certain, although Mitchell Act funding has been uncertain in recent years.

20.2.1.5 VSP Effects

Abundance –The hatchery program is increasing the number of natural spawners above and below North Fork Dam. In 2002, an estimated 31% of the fish recovered above North Fork Dam during spawning surveys were hatchery fish (Schroeder *et al.* 2004). Below North Fork Dam, the number of spawners has been less than 200 fish since 1992 and most of the fish are of hatchery origin (King 2004). It is unknown how many offspring the hatchery fish spawners are producing since hatchery and natural fish are intermixed on the spawning grounds. It is important to note, however, the number of spring chinook passing North Fork Dam averaged around 500 fish from 1960 to 1980. Counts increased to more than 2,000 fish in 1981, the first year of Clackamas Hatchery returns. Counts in subsequent years have numbered in the thousands with the return in 2003 being the highest on record (King 2004). From 2001 to 2003, the number of non-adipose fin-clipped fish passing North Fork Dam has been in the range of 2,000 to 3,500 fish.

Returns of spring chinook back to the hatchery facility have averaged 2,800 fish from 1980 to 2003 (Figure 20.4). Over the last 23 years, there have only been eight years when returns back to the hatchery were below the broodstock goal. However, many of the hatchery fish bypass the collection facility and continue migrating upstream. Collections of hatchery fish at North Fork Dam, upstream of the hatchery, have indicated in some years more hatchery fish are observed at the dam than are collected at the hatchery. In 2003, 3,500 fish were collected at the hatchery and 6,300 marked hatchery fish were collected upstream at North Fork Dam (King 2004). This program has demonstrated a steady return of hatchery fish in excess of broodstock needs. There appears to be little risk of not meeting the broodstock goal on an annual basis when hatchery fish can be collected at the hatchery and North Fork Dam.

Productivity – It is not known whether the hatchery program is increasing or decreasing the productivity (measured as the number of recruits produced per spawning fish) of the naturally spawning population. If hatchery fish were just as successful as natural fish, then the productivity rate of hatchery fish would be the same as natural fish. If hatchery fish spawning naturally resulted in fewer recruits the next generation compared to having no hatchery fish spawning naturally (all else being equal), then productivity of the natural population would be reduced by the hatchery program. It is difficult, if not impossible, to quantify the effects of naturally spawning hatchery fish on the natural population when many other environmental and habitat factors also contribute to the productivity of any brood year.

Since some hatchery fish are spawning naturally, there would be some benefits of the program by providing additional carcass nutrients to the ecosystem after the fish spawn and die. This could help increase juvenile fish production.

Spatial Structure – The Clackamas Hatchery program is not affecting the spatial structure of this population. Spring chinook can still access historic headwater habitat since fish ladders exist on River Mill and North Fork dams. Hatchery fish are not being reintroduced into unoccupied

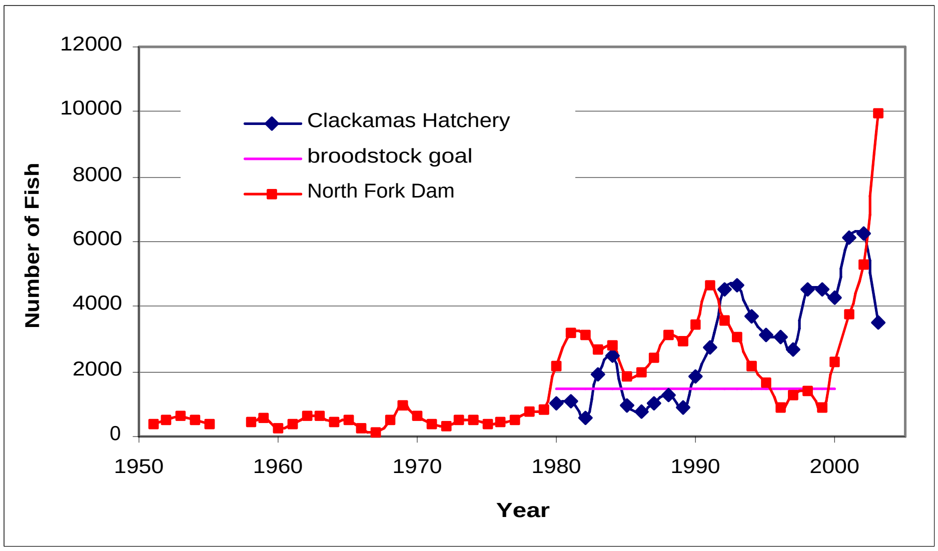

Figure 20.4. Returns of spring chinook to Clackamas hatchery and North Fork Dam. The first adult returns from the Clackamas hatchery began in 1980.

habitat. No hatchery weirs or hatchery facilities are impeding migration for spring chinook.

Diversity – The life history characteristics of hatchery spring chinook currently in the Willamette Basin differ from those of the historic run. The hatchery fish life history is simplified compared to natural fish. Most of the hatchery fish are released as age-1 smolts in the spring. Whereas in the historic populations, a more continuous emigration of smolts was observed through the fall and spring periods. Hatchery chinook return at an earlier age than the historic populations. Most of the returns now are age-4 fish instead of age-5 (Willis *et al.* 1995). Given these differences, there are potential risks from having hatchery fish interbreeding with the naturally spawning population. Over the last 20 years hatchery fish have undoubtedly interacted with the natural population on the spawning grounds. However, future management of the program is to reduce the number of hatchery fish spawning upstream of North Fork Dam so that a naturally produced run of spring chinook can be maintained. Natural-origin returns have been above critical run levels necessary to avoid demographic and genetic risks from low spawner numbers. Reestablishment of some natural life history diversity in the wild without the continual input of hatchery spawners should help long term viability of this population. Controlling the number of hatchery fish spawning in the wild will also allow the sustainability of the wild run to be evaluated over time without the masking effects of hatchery fish.

20.2.2 Molalla

The Molalla River historically supported a demographically independent population of spring chinook that is now extirpated, or nearly so (Myers *et al.* 2002). In recent years, nearly all of the natural spawners observed in the Molalla have been of hatchery-origin (Schroeder *et al.* 2004). Smolts from South Santiam hatchery have been stocked into the Molalla and represent most of the hatchery fish on the spawning grounds. Few redds have been observed from natural or hatchery fish. In 2003, a year of large returns of chinook throughout the Willamette Basin, Schroeder *et al.* (2004) observed 15 redds in over 11 miles of surveyed stream.

It is apparent the Molalla River does not support a viable population. The natural population is functionally extinct and the outlook for recolonization of the Molalla by natural-origin fish from other nearby areas is unlikely. The most promising hope for rebuilding a natural run of spring chinook is by using hatchery fish. The current stock of fish in the Molalla is from the South Santiam Hatchery. This stock of fish is not the ideal stock of fish to use for reintroduction efforts, but a local stock does not exist. It is unclear at this time whether the South Santiam stock would be the best hatchery stock. It seems a hatchery program could benefit the reestablishment of a natural population in the Molalla River once the most appropriate stock of fish and type of release (adult, fry, smolt) is determined. Habitat degradation is the primary factor limiting future production and recovery of a spring chinook population in the Molalla River. The high prespawning mortality rates of adult spring chinook in recent years (Figure 20.11) make the prospects of using hatchery fish to reestablish a self-sustaining run very poor.

20.2.3 North Santiam

The North Santiam River historically supported a population of spring chinook that numbered in the thousands (NMFS 2000). The current run of natural fish has averaged less than 400 adults crossing Bennett Dams on the lower North Santiam River from 2000 to 2003 (Schroeder *et al.* 2004). The actual number of natural fish surviving to spawn is even lower since pre-spawning mortality of adults has ranged from 52% to 75% from 2001 to 2003 in the North Santiam below Big Cliff Dam (Figure 20.11; Schroeder *et al.* 2004). This natural population is not sustaining itself at a viable level.

20.2.3.1 Program History

The current hatchery program began in 1950 after completion of Detroit and Big Cliff dams that blocked upstream access to approximately 70% of the spawning area for spring chinook. Broodstock have been collected from returns to the base of Big Cliff Dam or Minto collection facility (downstream a few miles from the dam). Prior to the current program, hatchery fish were released from both local and non-local sources since the first egg take in 1911 (Myers *et al.* 2002). The current program uses an integrated stock, and has not imported out of basin stocks.

20.2.3.2 Similarity between Hatchery-origin and Natural-origin Fish

Recent genetic analyses of hatchery and natural chinook in the North Santiam showed these stocks to be most closely related to other natural and hatchery runs in the Upper Willamette ESU (Myers *et al.* 2002). The hatchery component of the run was more closely related to natural fish in the McKenzie River than local, natural fish in the North Santiam. However, samples for each group were from different years. Myers *et al.* (2002) did not show a geographic pattern throughout the ESU, which was not expected, and stated relatively low sample sizes from juvenile fish may have produced misleading results for natural-origin fish.

20.2.3.3 Program Design

The program is to mitigate for federal dams in the basin and provide fish for harvest. All smolt releases are adipose fin-clipped. In recent years, the program has also been outplanting hatchery fish upstream of the impassable dams in the North Santiam to reintroduce fish back into historic habitat. All of the fish spawning above Detroit Dam have been hatchery fish. Below the dams, hatchery fish comprise more than 50% of the spawners. In the Little North Santiam River, natural fish collected from Minto trap have been outplanted to supplement natural spawning. The few fish surviving to spawn have been predominately natural fish.

20.2.3.4 Program Performance

The *smolt-to-adult* survival rate of the N. Santiam Hatchery stock has averaged 0.55% for brood years 1987-1996 (Figure 20.5; ODFW North Santiam HGMP 2004). The broodstock goal for the current production level is approximately 600 fish. Total returns of hatchery fish from this program has exceeded the broodstock goal since 1970 in all years except for 1979-80 (Figure 20.6). Only fish from local returns are used for broodstock (NMFS 2000). Funding for this program comes from Corps of Engineers and ODFW. The long-term funding outlook for this program is very certain.

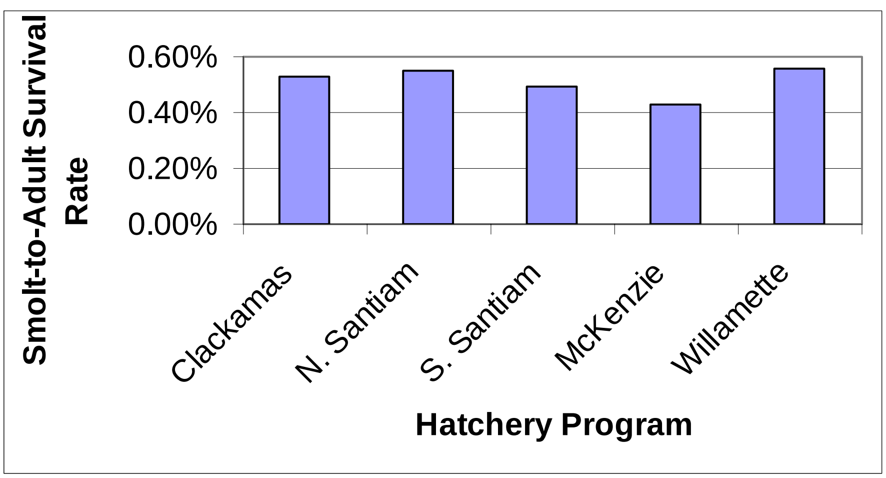

Figure 20.5. Average *smolt-to-adult* survival rates of spring chinook returning to hatchery facilities. Data are for brood years 1987-96 (ODFW South Santiam HGMP 2004).

20.2.3.5 VSP Effects

Abundance – Returns of hatchery fish to the North Santiam have numbered in the thousands annually. In 2003, the estimated run of hatchery spring chinook crossing the Bennett Dams exceeded over 12,000 fish (King 2004). Most of these hatchery fish are collected upstream at Minto Dam (the end of the line for natural upstream migration) and taken for broodstock or outplanted above Detroit Dam into historic habitat to spawn naturally. The unmarked chinook collected at Minto Dam have either been incorporated into the hatchery broodstock (very few) or outplanted to spawn in the Little North Santiam River (approximately 268 fish in 2003).

The recent management strategy has been to release only fin-clipped hatchery chinook above Detroit Dam. All unmarked fish have remained below Big Cliff Dam or have been outplanted in the Little North Santiam River. Survival of juvenile and adult chinook below the dams has been poor. Mortality rates of over-summering adults has been estimated at 50% to 75% from 2001-03. Even though there have been high numbers of hatchery fish available to spawn below the dams, most of these fish do not live to spawn. From 1997 to 2003, the number of redds observed in the North Santiam below the dams has typically been 100 to 200 (King 2004). The exception was in 2003 when over 800 redds were observed.

Based on the above information, it appears habitat conditions and the natural spawning of hatchery and natural fish below the dams over the last 20 years has not produced many natural origin fish in recent years (now that this can be determined since returning hatchery fish are adipose fin-clipped). This is in contrast to the Clackamas and McKenzie Rivers, where in recent years there have been a few thousand natural fish returning.

Productivity – It is not known whether the hatchery program is increasing or decreasing the

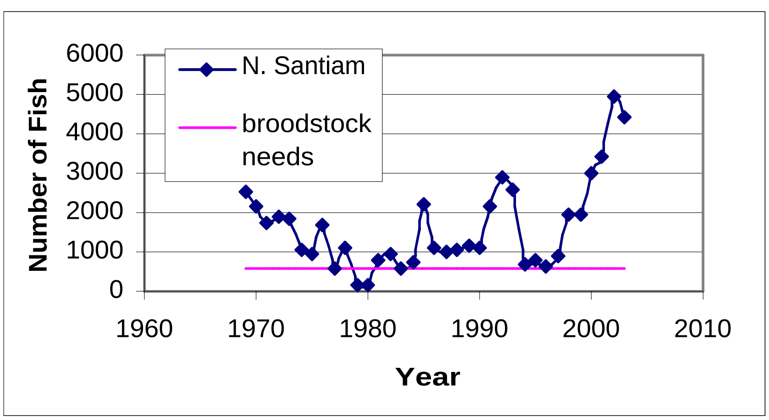

Figure 6. Return of spring chinook to Minto Hatchery collection facility on the North Santiam River.

productivity rate (the number of recruits produced per spawning fish) of the naturally spawning population. If hatchery fish were just as successful as natural fish, then the productivity rate of hatchery fish would be the same as natural fish. If hatchery fish spawning naturally resulted in fewer recruits the next generation compared to having no hatchery fish spawning naturally (all else being the same), then productivity of the natural population would be reduced by the hatchery program. It is difficult, if not impossible, to quantify what the effects of naturally spawning hatchery fish may be on the natural population when many other environmental and habitat factors also contribute to the productivity of any brood year.

Since some hatchery fish are spawning naturally, there are likely some benefits of the program by providing additional carcass nutrients to the ecosystem after the fish spawn and die. This could help increase overall fish productivity.

Spatial Structure – The North Santiam spring chinook hatchery program may benefit population spatial structure through the outplanting of adult hatchery into historic habitat above the impassable dams. Hatchery fish have been used because of the abundant returns. These fish were locally-derived from wild stock, and can be used to study juvenile survival downstream through Detroit and Big Cliff dams. Outplanting of hatchery fish above the dams also provides benefits to the spatial distribution of the population. If a catastrophe occurs or natural production fails below the dam, having spawners in historic habitat above the dam would provide some buffer against losses downstream.

It is feasible to outplant only unmarked, natural fish that are collected at Minto Dam to the areas above Detroit Dam and not allow any hatchery fish to interbreed with the wild fish (i.e. create a wild fish sanctuary area above the dam). However, the numbers of natural fish are so low that it was deemed genetic and demographic risks would be of concern. In addition, the relatively high mortality rates of downstream smolts emigrating by Detroit and Big Cliff dams would also be of concern for the few numbers of wild fish present.

Diversity – The life history characteristics of hatchery spring chinook currently in the Willamette Basin differ from those of the historic run. The hatchery fish life history is simplified compared to natural fish (Willis *et al.* 1995). Most of the hatchery fish are released as age-1 smolts in the spring. Whereas in the historic populations, a more continuous run of smolts was observed through the fall and spring periods. Hatchery chinook return at an earlier age than the historic populations. Most of the returns now are age-4 fish instead of age-5 (Willis *et al.* 1995). Given these differences, there are potential risks from having hatchery fish interbreeding with the naturally spawning population. Over the last 20 years hatchery fish have undoubtedly interacted with the natural population on the spawning grounds. Reestablishment of some natural life history diversity in the wild without the continual input of hatchery spawners should help long term viability of this population. Controlling the number of hatchery fish spawning in the wild will also allow the sustainability of the wild run to be evaluated over time without the masking effects of hatchery fish.

20.2.4 South Santiam

20.2.4.1 Program History

The current hatchery program in the South Santiam was initiated to mitigate for federal dams in the basin. Broodstock was collected from returns to the base of Foster Dam, an impassable dam that blocked access to nearly all of the historical spawning habitat in the basin. Prior to the existing program, broodstock had been taken from local returns since the early 1920's (Myers *et al.* 2002). The existing broodstock is integrated into the local population and has not imported fish from out of basin sources.

20.2.4.2 Similarity between Hatchery-origin and Natural-origin Fish

There are no genetic analyses available from the South Santiam River. However, due to the large numbers of hatchery fish spawning in the wild below Foster Dam for at least the last two decades, it is expected hatchery fish have introgressed into the natural population. Since hatchery fish make up most of the natural spawners, it is likely these fish are contributing to the overall production in the basin (Schroeder *et al.* 2004).

20.2.4.3 Program Design

The program is designed to mitigate fishery losses from federal dams in the basin and provide fish for commercial and recreational harvest. Fish from the hatchery program are likely integrated with the natural population because broodstock is collected from returns to the base of Foster Dam. Since the program was initiated it has likely incorporated natural-origin fish into the broodstock, although the exact levels are unknown because hatchery and natural fish could not be differentiated until recently. High numbers of program fish have been spawning below Foster Dam naturally for at least the last two decades and comprise the majority of spawners. Broodstock are collected throughout the entire run. All hatchery releases are 100% externally marked. It is likely hatchery and natural fish have a close resemblance due to past management practices and because the extent of hatchery fish spawners could not be controlled below Foster Dam. Current management is focused on developing a locally-adapted broodstock that incorporates some natural fish on an annual basis (NMFS 2000).

20.2.4.4 Program Performance

The smolt-to-adult survival rate of the South Santiam Hatchery stock has averaged 0.49% for brood years 1987-1996 (Figure 20.5; ODFW South Santiam HGMP 2004). The broodstock goal for the current production level is approximately 1,400 fish. Total returns of hatchery fish from this program has exceeded the broodstock goal every year for the last 20 years (Figure 20.7). Only fish from local returns are used for broodstock (NMFS 2000). Funding for this program comes from Corps of Engineers and ODFW. The long-term funding outlook for this program is very certain.

20.2.4.5 VSP Effects

Abundance – The South Santiam historically supported a large population of spring chinook that numbered in the thousands of fish annually (NMFS 2000). All of the historic spawning area was lost after the construction of federal dams in the basin with no upstream passage facilities. In the last two years (the first years when hatchery and natural fish could be differentiated), an estimated 829 and 546 natural-origin fish returned in 2002 and 2003 (Firman *et al.* 2003, 2004). These fish would have been produced from fish that spawned naturally in the area below Foster Dam, which were most likely predominately hatchery fish. In 2002, 86% of the carcasses recovered in this area were fish of hatchery origin (Schroeder *et al.* 2004). The program is increasing the number of spawners below Foster Dam.

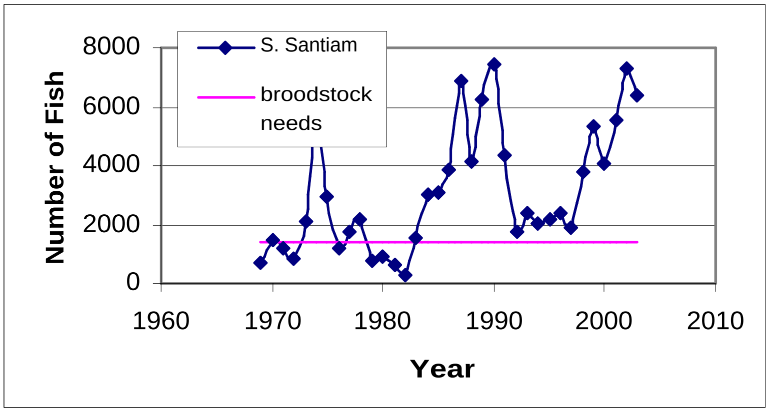

Figure 20.7. Return of spring chinook to South Santiam Hatchery collection facilities.

Natural and hatchery fish have been outplanted above Foster Dam in recent years in an effort to re-establish natural spawning in historic habitat. Of the fish released above Foster Dam in 2002 and 2003, hatchery fish represented 9% and 27% of the fish released, respectively (Firman *et al.* 2003, 2004). Spawning surveys were not conducted above the dam, so it is unknown how many of these fish actually survived until spawning.

The South Santiam Hatchery has averaged 3,025 fish at the collection facilities at the base of Foster Dam from 1969 to 2003. Returns have consistently exceeded broodstock goals since the early 1980s (Figure 20.7). Based on existing production goals, it appears the program is at little risk of not returning sufficient numbers of fish to meet broodstock goals.

Productivity – It is not known whether the hatchery program is increasing or decreasing the productivity rate (the number of recruits produced per spawning fish) of the naturally spawning population. If hatchery fish were just as successful as natural fish, then the productivity rate of hatchery fish would be the same as natural fish. If hatchery fish spawning naturally resulted in fewer recruits the next generation compared to having no hatchery fish spawning naturally (all else being the same), then productivity of the natural population would be reduced by the hatchery program. It is difficult, if not impossible, to quantify what the effects of naturally spawning hatchery fish may be on the natural population when many other environmental and habitat factors also contribute to the productivity of any brood year.

Since some hatchery fish are spawning naturally, there are likely some benefits of the program by providing additional carcass nutrients to the ecosystem after the fish spawn and die. This could help increase overall fish productivity.

Spatial Structure – The hatchery program is being used to reintroduce fish above Foster Dam (an impassable dam). In 2002 and 2003, approximately 70 and 151 finclipped hatchery fish were outplanted, respectively (Firman *et al.* 2003, 2004). An additional 695 and 401 unmarked adults were also outplanted. Additional supplementation in the areas above Foster Dam with hatchery fish may decrease some of the demographic risks associated with too few natural fish being outplanted.

***Diversity* –** The life history characteristics of hatchery spring chinook currently in the Willamette Basin differ from those of the historic run. The hatchery fish life history is simplified compared to natural fish (Willis *et al.* 1995). Most of the hatchery fish are released as age-1 smolts in the spring. Whereas in the historic populations, a more continuous run of smolts was observed through the fall and spring periods. Hatchery chinook return at an earlier age than the historic populations. Most of the returns now are age-4 fish instead of age-5 (Willis *et al.* 1995). Given these differences, there are potential risks from having hatchery fish interbreeding with the naturally spawning population. Over the last 20 years, hatchery fish have undoubtedly interacted with the natural population on the spawning grounds. Reestablishment of some natural life history diversity in the wild without the continual input of hatchery spawners should help long term viability of this population. Controlling the number of hatchery fish spawning in the wild will also allow the sustainability of the wild run to be evaluated over time without the masking effects of hatchery fish.

20.2.5 Calapooia

The Calapooia River historically supported a demographically independent population of spring chinook that is now extirpated, or nearly so (Myers *et al.* 2002). In recent years, nearly all of the natural spawners observed in the Calapooia have been of hatchery-origin (Schroeder *et al.* 2004). Live adults from South Santiam Hatchery stock have been outplanted into the Calapooia. However, their survival is poor and few survive to spawn. In 2003, a year of large returns of chinook throughout the Willamette Basin, Schroeder *et al.* (2004) observed two redds in nearly eight miles of surveyed stream.

It is clear the Calapooia River does not support a viable population. The natural population is likely extinct and the outlook for recolonization of the Calapooia by natural-origin fish from other nearby areas is unlikely. The most promising hope for rebuilding a small natural run of spring chinook is by using hatchery fish. The current stock of fish outplanted to the Calapooia is from the South Santiam hatchery. This stock of fish is not the ideal stock of fish to use for reintroduction efforts, but a local stock does not exist. It is unclear at this time whether the South Santiam stock would be the best hatchery stock. It seems a hatchery program could benefit the reestablishment of a natural population in the Calapooia River once the most appropriate stock of fish and type of release (adult, fry, smolt) is determined. The Calapooia will never likely support a large run of fish because of the small size of the subbasin.

20.2.6 McKenzie

20.2.6.1 Program History

Broodstock for hatcheries have been collected from the McKenzie River since 1902 (Myers *et al.* 2002). For the existing program, broodstock have been collected solely from local returns. It is unknown the extent to which natural fish have been incorporated into the broodstock in the past because hatchery fish could not be differentiated from natural fish. In recent years, information has shown approximately 10% of the broodstock have been natural-origin fish (Firman *et al.* 2004). NMFS (2000) imposed limits on the number of natural fish that could be used for broodstock because of concerns about mining the natural run since its status was unclear at that time due to unmarked hatchery fish. Future management will likely incorporate more than 10% natural fish into the broodstock.

20.2.6.2 Similarity between Hatchery-origin and Natural-origin Fish

The genetic analyses included in Myers *et al.* (2002) showed both hatchery and natural fish in the Willamette River Basin are very distinct from other chinook stocks in the Columbia River Basin. Within the Willamette River, the analyses showed significant differences between hatchery and natural fish, but there was no geographical pattern to the diversity (i.e. hatchery fish in the McKenzie were not most closely related to the natural fish in the McKenzie). Myers *et al.* (2002) stated the relatively low sample size of the natural fish from one juvenile age class may have produced misleading results for natural fish throughout the ESU.

Given the current hatchery program was founded from natural fish in the McKenzie River and the program has likely incorporated at least some natural fish into the broodstock over the years, and the high levels of hatchery fish spawning naturally, hatchery and natural fish probably show some genetic similarity.

20.2.6.3 Program Design

The hatchery program in the McKenzie is not intended to supplement natural spawning in the basin. However, the numbers of hatchery fish spawning in the wild cannot be adequately controlled. In recent years, the percentage of the total run passing Leaburg Dam that were hatchery fish has ranged from 33% to 43% from 2001 to 2003 (Firman *et al.* 2004).

Broodstock is collected throughout the entire run of spring chinook. All the juvenile smolts released from the program are adipose fin-clipped.

20.2.6.4 Program Performance

The *smolt-to-adult* survival rate of the McKenzie Hatchery stock has averaged 0.43% for brood years 1987-1996 (Figure 20.5; ODFW McKenzie HGMP 2004). The broodstock goal for the current production level is approximately 800 fish. Total returns of hatchery fish from this program has exceeded the broodstock goal nearly every year since 1969 (Figure 20.9). Funding for this program comes from Corps of Engineers and ODFW. The long-term funding outlook for this program is very certain.

20.2.6.5 VSP Effects

Abundance – The McKenzie River still supports a run of natural-origin fish that numbers in the thousands annually (King 2004). The number of natural fish passing Leaburg Dam in 2003 was more than 5,700 adults (the highest count since wild fish counting began in 1994). The average number of natural fish at Leaburg Dam from 1994 to 2003 is 2,100 adults. Most of the historic habitat is still naturally accessible to spring chinook in the McKenzie River. The downstream effects from the operation of Blue River and Cougar dams are not as problematic for spring chinook as have been observed below other federal dams in the Middle Fork, South Santiam, and North Santiam rivers. Prespawning mortality rates of adult spring chinook in the McKenzie are the lowest (7% to 21% for 2001-03) observed for any Willamette tributary (Schroeder *et al.* 2004).

The hatchery program has been increasing the number of natural spawners below and above Leaburg Dam (Firman *et al.* 2003, 2004; Schroeder *et al.* 2003, 2004). In recent years, hatchery fish have comprised 33% to 43% of the natural spawners above Leaburg Dam (Schroeder *et al.* 2004). Below Leaburg Dam, hatchery fish have comprised more than 70% of the natural spawners in 2003 (Firman *et al.* 2004). It is unknown if the high level of hatchery fish on the spawning grounds in recent years is representative of what occurred over the last few decades. It is possible hatchery fish spawning has been elevated in recent years because of the very high returns of both hatchery and natural fish since 2000 (Figure 20.8). The estimated total return of spring chinook to the McKenzie River has been more than 16,000 fish in 2002 and 2003- more than any year since 1970.

The hatchery program also outplants live adults above Cougar and Blue River dams (impassable dams in the headwaters of the McKenzie basin). In 2002 and 2003, more than three thousand hatchery fish have been outplanted above Cougar Dam into historic habitat in the South Fork McKenzie River (Firman *et al.* 2003, 2004). These adult outplants have produced smolts that have been observed downstream at Cougar Dam (M. Wade, ODFW, personal communication).

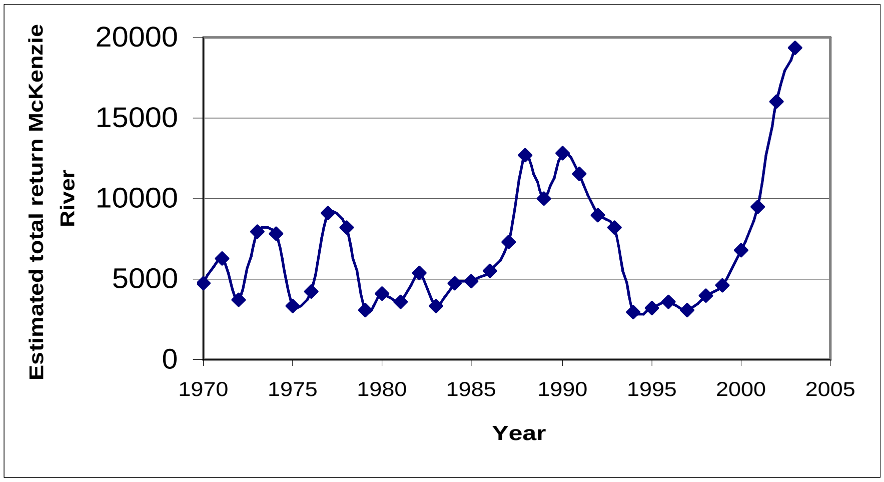

Figure 20.8. Estimated total return of natural and hatchery spring chinook to the McKenzie River (King 2004).

Returns of hatchery fish back to McKenzie Hatchery has been consistently above broodstock needs (Figure 20.9). Hatchery fish are also collected from Leaburg Dam when possible to help manage the percentage of hatchery fish spawning in the wild. In years when returns to the hatchery may be insufficient to meet broodstock needs, the trap at Leaburg Dam could be used to supplement hatchery needs. Since returns of hatchery fish have been high and two collection facilities are available, there appears to be little risk of not meeting broodstock needs, assuming current production levels.

Productivity – It is not known whether the hatchery program is increasing or decreasing the productivity rate (the number of recruits produced per spawning fish) of the naturally spawning population. If hatchery fish were just as successful as natural fish, then the productivity rate of hatchery fish would be the same as natural fish. If hatchery fish spawning naturally resulted in fewer recruits the next generation compared to having no hatchery fish spawning naturally (all else being the same), then productivity of the natural population would be reduced by the hatchery program. It is difficult, if not impossible, to quantify what the effects of naturally spawning hatchery fish may be on the natural population when many other environmental and habitat factors also contribute to the productivity of any brood year.

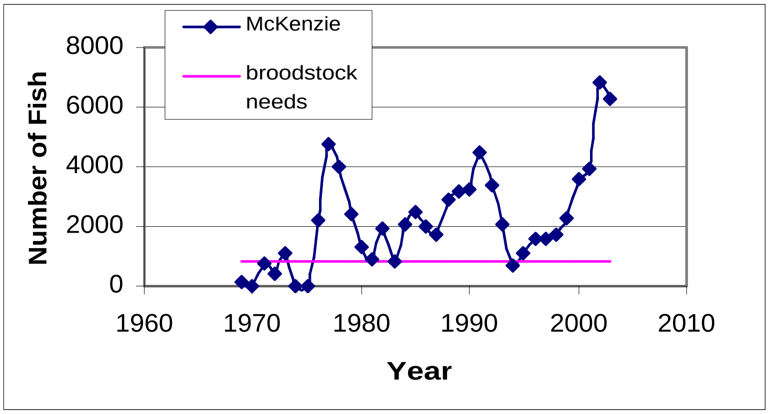

Figure 20.9. Estimated total return of hatchery and natural spring chinook to the McKenzie River (King 2004).

Since some hatchery fish are spawning naturally, there are likely some benefits of the program by providing additional carcass nutrients to the ecosystem after the fish spawn and die. This could help increase overall fish productivity.

Spatial Structure – The McKenzie Hatchery program is being used to reintroduce hatchery fish back into historic habitat that is blocked by Cougar and Blue River dams (Firman *et al.* 2004). In 2003 more than 3,800 hatchery fish were outplanted above Cougar Dam (Firman *et al.* 2004). The program is providing benefits to the overall spatial distribution of this population. However, there are concerns regarding the potential effects of having progeny from these hatchery fish outplants being indistinguishable from progeny produced by natural-origin spawners in the area above Leaburg Dam (the stronghold natural production area for the ESU). Given the potential risks of having large numbers of hatchery fish intermixing with the natural population, outplanting of hatchery fish above the impassable dams in the McKenzie is of concern.

No hatchery facilities or weirs are known to impede migration or the spawning distribution of this population. Leaburg Dam (owned and operated by Eugene Water and Electric Board) likely has affected the migration and spawning distribution of natural and hatchery fish.

Diversity – The life history characteristics of hatchery spring chinook currently in the Willamette Basin differ from those of the historic run. The hatchery fish life history is simplified compared to natural fish (Willis *et al.* 1995). Most of the hatchery fish are released as age-1 smolts in the spring. In the historic populations, a more continuous emigration of smolts was observed through the fall and spring periods. Hatchery chinook return at an earlier age than the historic populations. Most of the returns now are age-4 fish instead of age-5 (Willis *et al.* 1995). Given these differences, there are potential genetic introgression risks from having hatchery fish interbreeding with the naturally spawning population. Over the last 20 years hatchery fish have undoubtedly interacted with the natural population on the spawning grounds. Reestablishment of some natural life history diversity in the wild without the continual input of hatchery spawners should help long term viability of this population. Controlling the number of hatchery fish spawning in the wild will also allow the sustainability of the wild run to be evaluated over time without the masking effects of hatchery fish.

The McKenzie spring chinook hatchery program is of concern. Since the McKenzie supports the stronghold population of spring chinook for the ESU, it is important to closely manage potential risks from hatchery program on the natural population. In recent years, large numbers of hatchery fish have crossed Leaburg Dam even though NMFS (2000) directs the comanagers to minimize the number of hatchery fish spawning upstream of Leaburg Dam to the maximum extent possible. In 2003, approximately 40% of the spring chinook above Leaburg Dam were hatchery fish. The ladder and trap at Leaburg Dam do not allow large numbers of fish to be sorted efficiently while having minimal handling impacts to natural fish. Only a limited number of hatchery fish can be removed from the dam in years when large numbers of fish are present.

Hatchery fish straying into the only remaining significant wild fish production area in the ESU cannot be controlled adequately. This hatchery program, therefore, represents a risk to the natural population. This natural population would be a strong candidate for designation as a wild fish sanctuary area where hatchery effects would be minimal. However, this is not possible under the current hatchery program.

20.2.7 Middle Fork Willamette

20.2.7.1 Program History

The existing hatchery program was initiated in 1957 to mitigate for fishery losses associated with federal dams in Middle Fork basin. Dexter Dam, the lowermost dam, is impassable to fish. Broodstock for the hatchery was collected from returns to the Dexter trap. Since hatchery fish could not be differentiated from natural fish until 2002, it is unknown how many natural fish have been incorporated into the broodstock over the years. In the early years of the hatchery program, it is likely a significant number of natural fish were incorporated since natural fish were still abundant. In 2002 and 2003, less than 5% of the broodstock has been from natural fish (Firman *et al.* 2003, 2004). The long term intent of the program is to develop a broodstock that incorporates natural fish on a regular basis.

20.2.7.2 Similarity between Hatchery-origin and Natural-origin Fish

The genetic analyses included in Myers *et al.* (2002) showed both hatchery and natural fish in the Willamette River Basin are very distinct from other chinook stocks in the Columbia River Basin. In the Middle Fork basin, Myers *et al.* (2002) stated juvenile natural fish collected at Dexter Ponds were similar to other natural and hatchery stocks in the ESU. Only a limited amount of data are currently available. It is likely the hatchery stock is most closely related to natural fish more than any other run in the ESU since the broodstock was founded from local returns and hatchery fish have dominated the natural spawning in recent years (Schroeder *et al.* 2004).

20.2.7.3 Program Design

The program is designed to mitigate fishery losses from federal dams in the basin and provide fish for commercial and recreational harvest. High numbers of program fish have been outplanted above Dexter Dam in recent years and comprise the majority of spawners. However, the exact numbers of spawners is largely unknown because no spawning surveys are conducted. Broodstock are collected throughout the entire run. All hatchery releases are 100% externally marked. It is likely hatchery and natural fish have a close resemblance due to past management practices and because the extent of hatchery fish spawning could not be controlled below Foster Dam. The current management strategy focuses on developing a locally-adapted broodstock that incorporates some natural fish on an annual basis (NMFS 2000).

20.2.7.4 Program Performance

The smolt-to-adult survival rate of the Middle Fork hatchery stock has averaged 0.56% for brood years 1987-1996 (Figure 20.5; ODFW Middle Fork HGMP 2004). The broodstock goal for the current production level is approximately 1,600 fish. Total adult returns of hatchery fish from this program has exceeded the broodstock goal every year since 1969 (Figure 20.10). Funding for this program comes from Corps of Engineers and ODFW. The long-term funding outlook for this program is very certain.

20.2.7.5 VSP Effects

Abundance - The Middle Fork Willamette historically supported a large population of spring chinook that numbered in the thousands of fish annually (NMFS 2000). The primary production areas were lost from the construction of federal dams that inhibited upstream passage to over 345 kilometers of habitat (Myers *et al.* 2002). In 2002 and 2003, the only years when adipose fin-clipped hatchery fish could be differentiated from unmarked fish, an estimated 987 and 147 adults returned to Dexter Dam, respectively. However, subsequent analysis has shown that only 10% of the unmarked fish were actually naturally-produced fish, based on otolith readings (Schroeder *et al.* 2004). The unmarked fish were likely hatchery fish released as fry into the reservoirs in the Middle Fork. Therefore, the number of naturally-produced fish returning the last two years has been estimated at less than 100 fish in 2002 and 2003.

The number of fish (both hatchery- and natural-origin) spawning below Dexter Dam has been low in recent years due to poor over-summer survival (Figure 20.11; Schroeder *et al.* 2004). In

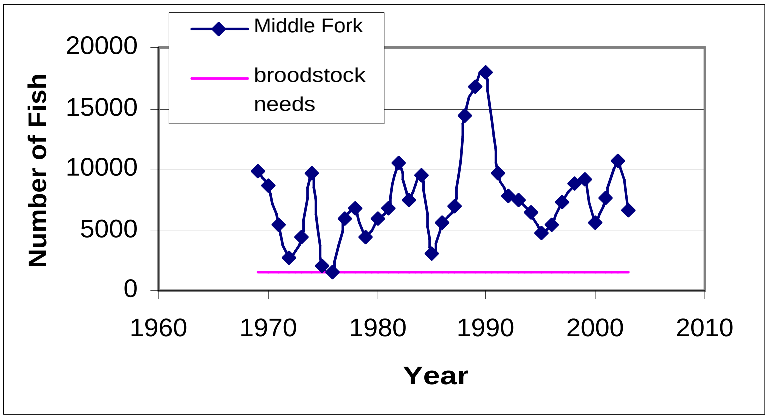

Figure 20.10. Return of spring chinook to Dexter Dam on the Middle Fork Willamette River.

2002 and 2003, prespawning mortality of adults was greater than 80%. In 2003, 14 redds were observed in 17 miles of surveyed area below Dexter Dam (2003 was a very high return year). Preliminary information also indicates spring chinook eggs have a very low survival rate (G. Taylor, USACE, personal communication). The limited number of natural fish observed the last two years were likely produced from juvenile and adult hatchery fish outplanted above Dexter Dam (ODFW Middle Fork HGMP 2004).

Since the number of natural-origin fish returning to the Middle Fork is extremely low, the hatchery program may help reestablish a natural run of fish above the impassable dams. The best stock of fish to use for recovery efforts is probably found in the Middle Fork hatchery stock, which was originally founded from local returns and has likely incorporated some natural fish into the broodstock over the years. The hatchery program is increasing the number of spawners below and above Dexter Dam and in Fall Creek, a tributary to the Middle Fork (Firman *et al.* 2004). In 2003 more than 3,800 spring chinook were outplanted above Dexter/Lookout Point dams.

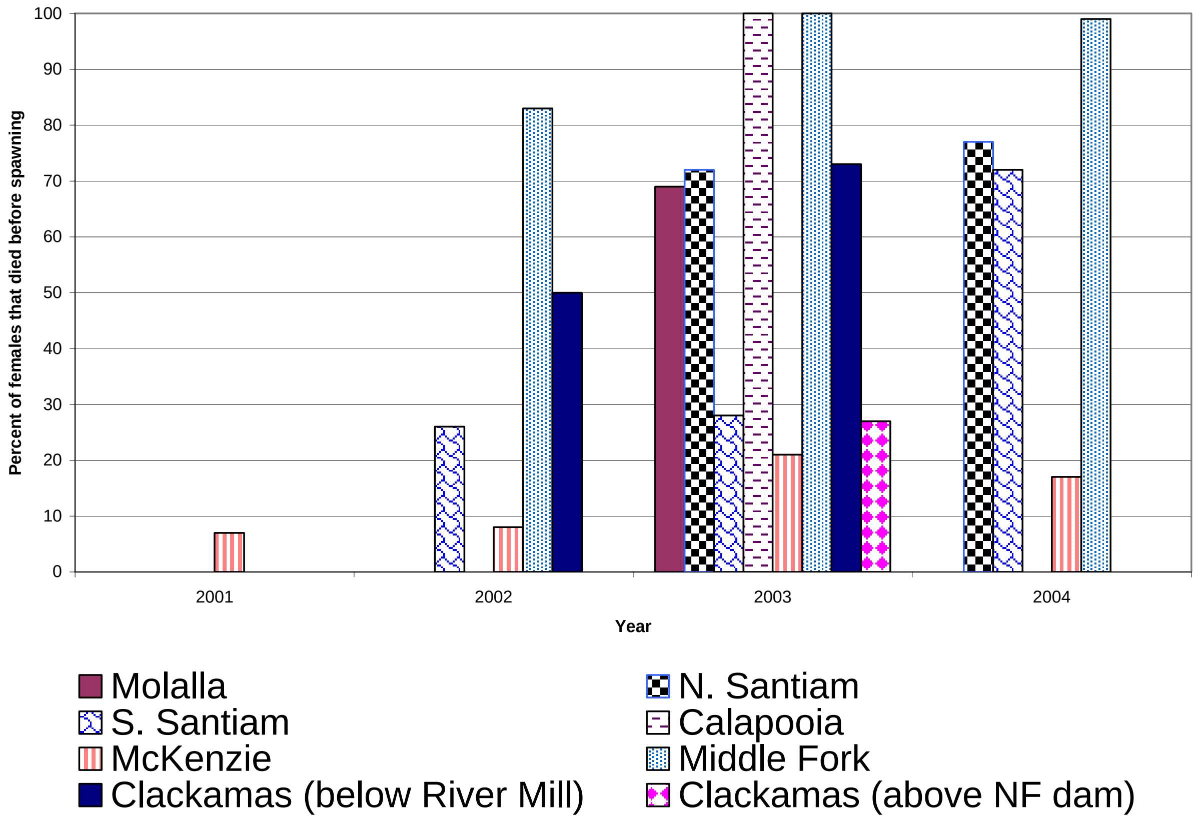

Figure 20.11. Estimated prespawning mortality rates in each population area. Estimated by the percentage of females carcasses that had not spawned (Schroeder *et al.* 2004).

Returns of hatchery fish to the Dexter Dam trap, where broodstock are collected, are the highest of all the program in the Willamette Basin (Figure 20.10). From 1969 to 2003, an average of 7,500 fish have been collected annually at the trap. Since 1969, the broodstock goal has been attained every year from local returns.

Productivity – It is not known whether the hatchery program is increasing or decreasing the productivity rate (the number of recruits produced per spawning fish) of the naturally spawning population. If hatchery fish were just as successful as natural fish, then the productivity rate of hatchery fish would be the same as natural fish. If hatchery fish spawning naturally resulted in fewer recruits the next generation compared to having no hatchery fish spawning naturally (all else being the same), then productivity of the natural population would be reduced by the hatchery program. It is difficult, if not impossible, to quantify what the effects of naturally spawning hatchery fish may be on the natural population when many other environmental and habitat factors also contribute to the productivity of any brood year.

Since some hatchery fish are spawning naturally, there are likely some benefits of the program by providing additional carcass nutrients to the ecosystem after the fish spawn and die. This could help increase overall fish productivity.

Spatial Structure **–** The hatchery program is benefitting the spatial distribution of the Middle Fork population because hatchery fish are being outplanted above the impassable dams into historic habitat. Since egg and adult survival is poor below Dexter Dam, outplanting fish back into the headwaters will likely result in more fish production, even though downstream survival through the dams is not high.

Diversity **–** The life history characteristics of hatchery spring chinook currently in the Willamette Basin differ from those of the historic run. The hatchery fish life history is simplified compared to natural fish (Willis *et al.* 1995). Most of the hatchery fish are released as age-1 smolts in the spring. In the historic populations, a more continuous emigration of smolts was observed through the fall and spring periods. Hatchery chinook return at an earlier age than the historic populations. Most of the returns now are age-4 fish instead of age-5 (Willis *et al.* 1995).

20.3 CONCLUSION

Existing Status: Threatened
BRT Finding: Threatened
Recommendation: Threatened

20.3.1 ESU Overview

20.3.1.1 History of Populations

The Willamette/Lower Columbia Technical Recovery Team identified seven historic populations of spring chinook within the Upper Willamette ESU (Myers *et al.* 2002). Most of these populations are nearly extirpated, with very low numbers of natural-origin fish returning in recent years. The McKenzie and Clackamas Rivers support the highest numbers of naturally produced spring chinook in the ESU.

20.3.1.2 Association between Natural Populations and Artificial Propagation

Natural populations "with minimal genetic contribution from hatchery fish" **–** There are no populations within the ESU that likely have minimal genetic contribution from hatchery fish. All of the seven populations have varying degrees of hatchery fish spawning in the wild. In the McKenzie River (the stronghold natural fish production area), hatchery fish have comprised more than 30% of the natural spawners in the basin since 2001 when hatchery fish could be differentiated from natural fish. Most of the other populations have predominately hatchery fish spawners.

Natural[a] populations "that are stable or increasing, are spawning in the wild, and have

[a] See HLP for definition of natural, mixed and hatchery populations

adequate spawning and rearing habitat"[b] – There are no natural populations within the ESU that do not have an associated hatchery program. The McKenzie and Clackamas Rivers currently support the most spawning habitat that is still naturally accessible to spring chinook. Natural fish returns to these areas have increased in recent years. However, the long term trends are still negative. Hatchery fish returns exceed natural fish returns in both of these basins.

Mixed (Integrated Programs[c]) – All of the populations identified in the ESU have integrated hatchery stocks.

Hatchery (Isolated[d]) – None.

20.3.2 Summary of ESU Viability

20.3.2.1 Abundance

The highest risk factors for this ESU are low abundance of natural fish and reduced spatial structure of the populations (BRT 2003). The first year natural fish could be differentiated from hatchery fish based on mass marking for this ESU was in 2002 (through age 5 fish). In the last two years, approximately 10% of the returns to the Willamette River have been unmarked fish (King 2004). Most of the natural fish return to the Clackamas and McKenzie Rivers. All of the other populations have very low numbers of natural fish returning. There is concern about the very high mortality rates (70% to 100%) of adult fish prior to spawning in most rivers. Less than a few hundred natural fish have been estimated returning to the Middle Fork Willamette and North Santiam Rivers in 2002 and 2003. The low returns of natural fish to the rivers and prespawn mortality rates in excess of 50% (Schroeder *et al.* 2004) results in few naturally-produced spawners for these populations. Critically low abundances of natural origin spawners occurs in the Molalla, North Santiam, Calapooia, and Middle Fork populations. See the Results Section for further information on returns to each river.

20.3.1.2 Productivity

Information on the productivity rates (recruits per spawner) of naturally spawning fish in each of the populations within the ESU is sparse. Productivity rates have likely been less than one for most, if not all, of the populations over the last several decades since natural fish abundance has been steadily declining. All of the rivers have a substantial number of naturally spawning hatchery fish. It is unknown whether the hatchery fish spawners are increasing or decreasing the productivity rate of the local population spawning in the wild. In the areas downstream of the impassable dams, habitat conditions and water quality are probably the most limiting factor and

---

[b] HLP Point 3

[c] Integrated programs follow practices designed to promote and protect genetic diversity and only use fish from the same local population for broodstock (both natural-origin fish, whenever possible, and hatchery-origin fish derived from the same local population and included in the ESU). Programs operated to protect genetic diversity in the absence of natural-origin fish (e.g., captive broodstock programs and the reintroduction of fish into vacant habitat) are considered "integrated".

[d] Isolated programs do not follow practices designed to promote or protect genetic diversity. Fish that are reproductively isolated are more likely to diverge genetically from natural populations included in the ESU and to be excluded themselves from the ESU.

not the abundance of hatchery fish spawners.

In the areas upstream of the dams where hatchery fish have been outplanted as adults, monitoring has shown these fish are producing outmigrating smolts (e.g. above Cougar Dam on the McKenzie River). These outplanting efforts are likely resulting in more fish production in the ESU. However, it is unknown if the hatchery programs are resulting in a benefit to the overall productivity rate of the ESU.

20.3.1.3 Spatial Structure

The highest risk factors for this ESU are low abundance of natural fish and reduced spatial structure of the populations (BRT 2003). Most of the historic spawning habitat in the ESU is now blocked by impassable dams. In the North Santiam, South Santiam, and Middle Fork basins, the most productive spring chinook habitat is no longer naturally accessible to fish. Recently, hatchery fish have been outplanted above the dams in an effort to reintroduce fish back into historic habitats. It is unknown how successful these efforts will be in producing fish due to the high mortality rates of smolts emigrating through the reservoirs and dams. However, expanding the distribution of spring chinook back into historic habitats is probably beneficial, especially given the high pre-spawn mortality rates that have been observed for adult fish residing below the dams (Schroeder *et al.* 2004).

20.3.1.4 Diversity

Hatchery fish have a simplified life history compared to natural fish in the ESU. Most hatchery fish are released as age-1 smolts in the spring and return as adults at a younger age and later in the year than the historic natural run of fish (Willis *et al.* 1995). All of the hatchery stocks in the Willamette Basin are still more closely related to one another than other spring chinook stocks outside the Willamette Basin. The programs are now being managed to develop locally-adapted broodstocks and all interbasin stock transfers have been eliminated, which will likely help reestablish some stock diversity throughout the ESU.

20.3.3 Artificial Propagation Record

20.3.3.1 Experience with Integrated Programs

The Clackamas, North Santiam, South Santiam, McKenzie, and Middle Fork hatchery stocks were derived from spring chinook returning to the Willamette River. These hatchery stocks resemble other Willamette stocks more than chinook stocks from outside the basin (Myers *et al.* 2002). All of these programs have been in operation for at least two decades.

20.3.3.2 Data on Whether Integrated Programs Are Self-sustaining

All of the current hatchery programs in the Willamette Basin produce adult returns in excess of broodstock goals. Spawner to spawner replacement rates have averaged more than one since the programs have been in operation. See “Results” section for further information.

20.3.3.3 Certainty that Integrated Programs Will Continue to Operate

Funding for all of the programs is certain since the programs are mitigation for fishery losses associated with dams in the Willamette Basin. In recent years, monitoring and evaluation supporting effective adaptive management are strengths of these propagation programs.

20.3.4 Summary of Overall Extinction Risk Faced by the ESU

There are significant concerns in all risk factors for the Upper Willamette River spring chinook ESU. Recent improvements in the total return of spring chinook to the Willamette River since 1997 has been positive. In 2002 and 2003 (the first years hatchery fish could be distinguished from natural fish), the estimated returns of unmarked fish to the Molalla, North Santiam, Calapooia, and Middle Fork Rivers has been low. These low returns and recent information showing very high mortality rates of adult fish prior to spawning, results in critically low abundances of spawners in these areas. The number of natural spawners in the Clackamas above North Fork Dam and the McKenzie above Leaburg Dam has shown improvements in recent years and these areas represent the stronghold spawning areas for the ESU. However, even in the Clackamas and McKenzie Rivers, a substantial number of the spawners are of hatchery-origin, which confounds the assessment of whether these two populations are in fact self-sustaining. It is unknown if the hatchery programs will be successful at reintroducing spring chinook above the impassable dams back into historic habitat, given the downstream and upstream passage constraints.

20.4 LITERATURE CITED

BRT (Biological Review Team). 2003. NOAA Fisheries Status Review. Preliminary conclusions regarding the updated status of listed ESUs of West Coast salmon and steelhead: Chinook Salmon ESUs. Available from NOAA Fisheries, NWFSC. Montlake, WA.

Firman, J., R. Schroeder, R. Lindsay, K. Kenaston, and M. Hogansen. 2003. Work completed for compliance with the Biological Opinion for hatchery programs in the Willamette Basin, USACE funding: 2002. Oregon Department of Fish and Wildlife. Corvallis.

__. 2004. Work completed for compliance with the Biological Opinion for hatchery programs in the Willamette Basin, USACE funding: 2003. Oregon Department of Fish and Wildlife. Corvallis.

King, S. 2003. Fisheries management and evaluation for 2002 Willamette spring chinook. Oregon Department of Fish and Wildlife annual report for ESA Fisheries Management and Evaluation Plan.

__. 2004. Fisheries management and evaluation for 2003 Willamette spring chinook. Oregon Department of Fish and Wildlife annual report for ESA Fisheries Management and Evaluation Plan.

Mattson, C.R. 1963. An investigation of adult spring chinook salmon of the Willamette river system. Fish Commission of Oregon. Clackamas, Oregon. 39 p.

Myers, J., C. Busack, D. Rawding, and A. Marshall. 2002. Identifying historical populations of chinook and chum salmon and steelhead within the Lower Columbia River and Upper Willamette River Evolutionarily Significant Units. Comanager review draft. Willamette/Lower Columbia Technical Recovery Team. NOAA Fisheries Seattle, WA.

NMFS (National Marine Fisheries Service). 2000. Endangered Species Act Section 7 consultation. Biological Opinion on the impacts from the collection, rearing, and release of salmonids associated with artificial propagation programs in the Upper Willamette spring chinook and winter steelhead Evolutionarily Significant Units. NMFS Northwest Region. Portland, OR.

ODFW (Oregon Department of Fish and Wildlife). 2004. Hatchery and Genetic management plan. Draft. McKenzie River spring chinook. Salem, OR.

__. 2004. Hatchery and Genetic management plan. Draft. Middle Fork Willamette River spring chinook. Salem, OR.

__. 2004. Hatchery and Genetic management plan. Draft. North Santiam River spring chinook. Salem, OR.

__FW (Oregon Department of Fish and Wildlife). 2004. Hatchery and Genetic management plan. Draft. South Santiam River spring chinook. Salem, OR.

Schroeder, R. K., K. R. Kenaston, R. B. Lindsay. 2002. Spring chinook salmon in the Willamette and Sandy rivers. FY 2001 annual progress report. Oregon Department of Fish and Wildlife. Corvallis, OR.

__. 2003. Spring chinook salmon in the Willamette and Sandy rivers. FY 2002 annual progress report. Oregon Department of Fish and Wildlife. Corvallis, OR.

__. 2004. Spring chinook salmon in the Willamette and Sandy rivers. FY 2003 annual progress report. Oregon Department of Fish and Wildlife. Corvallis, OR.

Willis, C. F., S. P. Cramer, D. Cramer, M. Smith, T. Downey, and R. Montagne. 1995. Status of Willamette River spring chinook salmon in regards to the Federal Endangered Species Act. Part 1. Portland General Electric Company and Eugene Water and Electric Board. 74 p.

21.0 UPPER WILLAMETTE WINTER STEELHEAD ESU

21.1 BACKGROUND

21.1.1 Description of the ESU

The following are historical winter steelhead populations that have been identified by the Technical Recovery Team (Myers *et al.* 2002) for the Upper Willamette winter steelhead evolutionarily significant unit (ESU).

21.1.1.1 Molalla

The population of steelhead in the Molalla River includes only naturally-produced winter run fish. No hatchery winter or summer steelhead have been released into the Molalla River since the late 1990s.

21.1.1.2 North Santiam

The population of steelhead in the North Santiam River includes only naturally-produced winter run fish. No hatchery winter steelhead have been released into the North Santiam River since the late 1990s. Hatchery summer steelhead from South Santiam hatchery stock are released into the North Santiam River. However, this hatchery stock is not part of the North Santiam population or Upper Willamette ESU because the summer run was introduced into the Willamette Basin from Skamania stock (out of the ESU).

21.1.1.3 South Santiam

The population of steelhead in the South Santiam River includes only naturally-produced winter run fish. No hatchery winter steelhead have been released into the South Santiam River since the late 1990s. Hatchery summer steelhead from South Santiam hatchery stock are released. However, this hatchery stock is not part of the South Santiam population or Upper Willamette ESU because the summer run was introduced into the Willamette Basin from Skamania stock (out of the ESU).

21.1.1.4 Calapooia

The population of steelhead in the Calapooia River includes only naturally-produced winter run fish. No hatchery winter steelhead or summer steelhead have been released into the Calapooia River since the late 1990s.

21.1.1.5 Westside Tributaries

It is unclear if the westside tributaries (Tualatin, Yamhill, Rickreal, and Luckiamute rivers) represent a historic, independent population of winter steelhead. However, naturally-reproduced winter steelhead would be included in the ESU. No hatchery winter or summer steelhead are released into the westside tributaries.

Table 2. List of natural winter steelhead populations identified by the Lower Columbia/Willamette TRT (Myers et al. 2002) for the Upper Willamette winter steelhead ESU, hatchery stocks released in each population area, and a description of the current hatchery program.

TRT populations	Hatchery Program (included, not included ESU)	Integrated or Isolated Program	Program description	Size of program (smolts)	Year in operation
Molalla winter steelhead	none				
North Santiam winter steelhead	S. Santiam summer steelhead (not included ESU)	isolated	smolt	161,500	1973
South Santiam winter steelhead	S. Santiam summer steelhead (not included ESU)	isolated	smolt	144,000	1973
Calapooia winter steelhead	none				
Westside Tributaries winter steelhead	none				

21.1.2 Status of the ESU

The BRT (2003) was encouraged by significant increases in adult returns (exceeding 10,000 total fish) in 2001 and 2002 for the Upper Willamette River *O. mykiss* ESU. The recent 5-year mean abundance, however, remains low for the entire ESU (5,819 adults), and individual populations remain at low abundance. Long-term trends in abundance are negative for all populations in the ESU, reflecting a decade of consistently low returns during the 1990s. Short-term trends, buoyed by recent strong returns, are positive. The ESU continues to be spatially well distributed in the four major subbasins in the ESU (the Molalla, North Santiam, South Santiam, and Calapooia Rivers), however, approximately one-third of the ESUs historical spawning habitat is now blocked. There is some uncertainty about the historical occurrence of *O. mykiss* in the Oregon Coastal Range drainages, but because coastal cutthroat trout is a dominant species in the Willamette basin *O. mykiss* are not as widespread in this ESU as they are east of the Cascade Mountains. The BRT considered the cessation of the “early” winter-run hatchery program a positive sign for ESU diversity risk, but remained concerned that releases of non-native summer steelhead continue. Because coastal cutthroat trout is dominant in the basin, resident *O. mykiss* are not as abundant or widespread here as in the inland *O. mykiss* ESUs. The BRT did not consider resident fish to reduce risks to ESU abundance, and their contribution to ESU productivity, spatial structure, and diversity is uncertain.

The BRT (2003) found moderate risks for each of the VSP categories. Based on this risk assessment, the majority opinion of the BRT was that the Upper Willamette River *O. mykiss* ESU is “likely to become endangered within the foreseeable future.” The minority BRT opinion was that the ESU is “not in danger or extinction or likely to become endangered within the foreseeable future.”

All of the current steelhead hatchery programs are isolated from the natural stocks. Only non-native summer steelhead are released in the ESU.

21.2 ASSESSMENT OF THE HATCHERY PROGRAM(S)

No hatchery steelhead that are included in the Upper Willamette winter steelhead ESU are currently being released. Only non-native hatchery summer steelhead are released into the South and North Santiam rivers. Hatchery fish are also released into the Clackamas, McKenzie, and Middle Fork Willamette Rivers. However these areas are not within the geographic boundaries of the Upper Willamette ESU. The purpose of the hatchery summer steelhead program in the Willamette Basin is harvest mitigation. Since summer run are introduced in the Willamette Basin, the management goal is not minimize the potential negative effects of this hatchery program on native winter steelhead. This includes minimizing the number of summer run spawning naturally, minimizing juvenile interactions after summer run smolts are released, and minimizing the incidental fishery effects on winter steelhead from anglers targeting summer steelhead.

Since only hatchery fish that are not included in the ESU are being released, there would be no benefits to VSP parameters for the ESU. Some new information on summer steelhead spawning is now available that was not considered by the BRT in 2003. This new information is included in the following population by population assessment.

21.2.1 Molalla

Hatchery steelhead are no longer released into the Molalla River. However, Firman and Buckman (2003) observed low densities of summer steelhead spawning in the mainstem Molalla River, Abiqua Creek, North Fork Molalla River, Cougar Creek, and Lost Creek in 2003 (Figure 21.2). Since summer steelhead are not native to the Upper Willamette River, the summer steelhead hatchery program is a risk to listed winter steelhead. Studies have shown adverse effects from non-native summer run on native winter run, especially when summer run spawn in the same areas as winter run fish (Chilcote 1998). Summer steelhead represent a risk to the abundance, productivity, spatial structure, and diversity of the Molalla winter steelhead population.

21.2.2 North Santiam

Non-native hatchery summer steelhead are released in the North Santiam River. Recent information suggests not all of the summer steelhead returning are harvested by anglers. Firman and Buckman (2003) observed low to high densities of summer steelhead spawning in the mainstem North Santiam River, Rock Creek, Mad Creek, Elkhorn Creek, and Sinker Creek in 2003 (Table 21.1; Figure 21.1). The North Santiam River had the highest densities of summer steelhead redds observed in any of the winter steelhead populations in the ESU. Studies have shown adverse effects from non-native summer run on native winter run because the summer run spawn earlier and thus can gain a competitive advantage once the progeny hatch and rear in the stream (Chilcote 1998). Summer steelhead were observed spawning from January through March. Native winter run spawning occurs from March through June. Any natural production by non-native summer run would be a risk to the abundance, productivity, spatial structure, and diversity of the North Santiam winter steelhead population.

21.2.3 South Santiam

Hatchery summer steelhead are released in the South Santiam River. Recent information suggests not all of the summer steelhead returning are harvested by anglers. Firman and Buckman (2003) observed low densities of summer steelhead spawning in the mainstem South Santiam River, Wiley, Crabtree, and Thomas Creek in 2003. Studies have shown adverse effects from non-native summer run on native winter run because the summer run spawn earlier and thus can gain a competitive advantage once the progeny hatch and rear in the stream (Chilcote 1998). Summer steelhead were observed spawning from January through March. Native winter run spawning occurs from March through June. Any production by non-native summer run would be a risk to the abundance, productivity, spatial structure, and diversity of the South Santiam winter steelhead population.

21.2.4 Calapooia

Hatchery summer steelhead are not released in the Calapooia River. Few summer steelhead have been observed in recent years in the Calapooia River. In 2003, Firman and Buckman (2003) did not find any summer run redds in three surveys conducted in the headwaters of the Calapooia Basin. However, winter run redds were observed later in the winter. This information suggests the summer steelhead program may not affect the Calapooia winter steelhead population. However, only one year of data has been collected. Any production by non-native summer run would be a risk to the local winter steelhead population.

Table 21.2. Comparison of summer steelhead (StS) and winter steelhead (StW) redd counts in 2003 on traditional surveys. Average and maximum values for winter steelhead are based on 17 to 30 years of data. Table from Firman and Buckman (2003).

Subbasin	Stream	StS Redds	StW Redds	Avg StW Redds	Max StW Redds
N Santiam River	Rock Cr.	19	49	6	16
N Santiam River	Mad Cr.	26	27	40	77
N Santiam River	Elkhorn Cr.	6	18	9	31
N Santiam River	Sinker Cr.	14	13	24	63
S Santiam River	Wiley Cr, upper	2	19	4	11
S Santiam River	Wiley Cr, lower	1	16	10	26
S Santiam River	Crabtree Cr.	0	6	27	93
S Santiam River	Thomas Cr.	2	13	17	35
Calapooia River	N Fk Calapooia	0	11	15	76
Calapooia River	Potts Cr	0	2	8	15

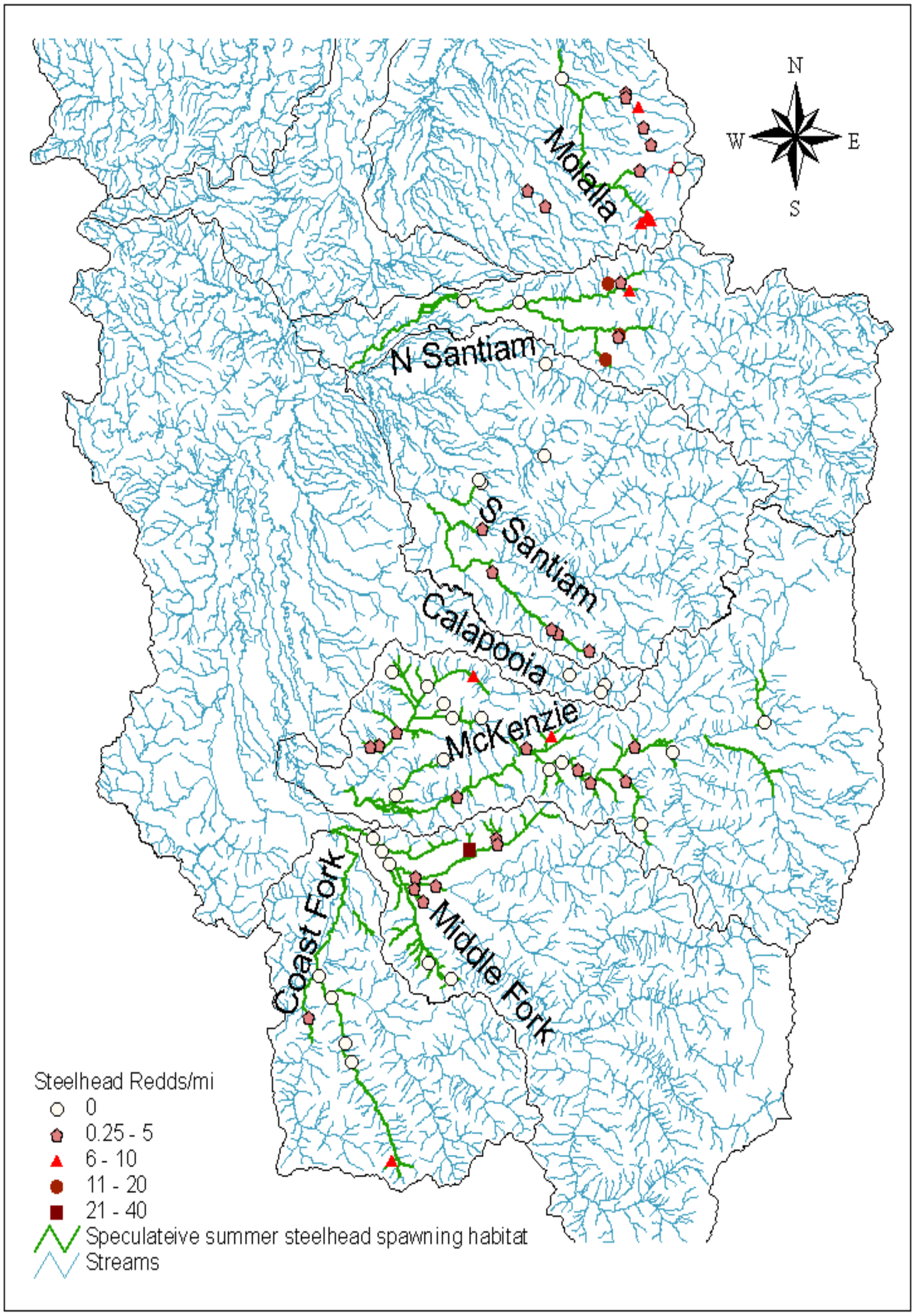

Figure 21.1. Summer steelhead redd densities in randomly selected surveys and traditional winter steelhead surveys in the Upper Willamette ESU, 2003. Summer steelhead are not included in the ESU. From Firman and Buckman (2003).

21.2.5 Westside Tributaries

It is unclear if the tributaries (Tualatin, Yamhill, Rickreal, and Luckiamute rivers) on the westside of the Willamette River Basin represent an historic, independent population of winter steelhead (Myers *et al.* 2002). However, no hatchery steelhead are released currently into any of these tributaries. Summer steelhead spawning surveys have not been conducted in these tributaries. However, it is presumed spawning of non-native steelhead would be low due to low stream flows during the migration period of summer run.

21.3 CONCLUSION

Existing Status: Threatened
BRT Finding: Threatened
Recommendation: Threatened

21.3.1 ESU Overview

21.3.1.1 History of Populations

The Willamette/Lower Columbia Technical Recovery Team identified four historic populations (Molalla, North Santiam, South Santiam, and Calapooia) of winter steelhead in the Upper Willamette winter steelhead ESU (Myers *et al.* 2002). The TRT was uncertain whether the Westside tributaries represented an independent population historically. Summer steelhead were not present historically above Willamette Falls and thus not included in the ESU.

21.3.1.2 Association between Natural Populations and Artificial Propagation

Natural populations "with minimal genetic contribution from hatchery fish" – There are currently no hatchery winter steelhead programs in the ESU. The last winter steelhead program was eliminated in 1998. Therefore all of populations likely have minimal genetic contribution from hatchery winter steelhead.

Natural[e] populations "that are stable or increasing, are spawning in the wild, and have adequate spawning and rearing habitat"[f] – The BRT (2003) did not identify any of the winter steelhead populations as being self-sustaining. All of the abundance trends over the last 20 to 30 years have been strongly downward.

Mixed (Integrated Programs[g]) – There are no hatchery winter steelhead programs in the ESU. Hatchery summer steelhead programs are not included as part of the ESU.

---

[e] See HLP for definition of natural, mixed and hatchery populations

[f] HLP Point 3

[g] Integrated programs follow practices designed to promote and protect genetic diversity and only use fish from the same local population for broodstock (both natural-origin fish, whenever possible, and hatchery-origin fish derived from the same local population and included in the ESU). Programs operated to protect genetic diversity in the absence of natural-origin fish (e.g., captive broodstock programs and the reintroduction of fish into vacant habitat) are considered "integrated".

Hatchery (Isolated[h]) – No hatchery programs are included as part of the ESU. Summer steelhead programs are not included in the ESU.

21.3.2 SUMMARY OF ESU VIABILITY

21.3.2.1 Abundance

The BRT (2003) showed all available abundance estimates exhibiting downward trends over the last 20 to 30 years. There have been recent increases in the abundance of natural fish. However, even the recent improvements are less than abundances observed prior to the early 1990s.

21.3.2.2 Productivity

Long-term productivity rates have averaged less than one.

21.3.2.3 Spatial Structure

All of the populations have been affected by habitat degradation or impassable barriers that have reduced the amount of spawning and rearing habitat available for the ESU.

21.3.2.4 Diversity

The elimination of winter steelhead programs using Big Creek stock (out of ESU) benefited the conservation of the ESU. There is still concern regarding the impacts from the non-native summer steelhead hatchery programs and the intermixing of summer and winter fish on the spawning grounds.

21.3.3 Artificial Propagation Record

21.3.3.1 Experience with Integrated Programs

There are no integrated programs included as part of the ESU.

21.3.3.2 Data on Whether Integrated Programs Are Self-sustaining

Not applicable.

21.3.3.3 Certainty that Integrated Programs Will Continue to Operate

There are no integrated programs that are included as part of the ESU.

[h] Isolated programs do not follow practices designed to promote or protect genetic diversity. Fish that are reproductively isolated are more likely to diverge genetically from natural populations included in the ESU and to be excluded themselves from the ESU.

21.3.4 Summary of Overall Extinction Risk Faced by the ESU

There have been increases in abundance of most steelhead populations in the ESU since 2000. However, long-term trends in abundance of all the monitoring areas are strongly downward. The BRT could not identify any of the populations as being self-sustaining. There is also concern about the loss of habitat from degradation or blockage by dams. The non-native summer steelhead hatchery programs in the Willamette Basin are a risk to the conservation of the ESU.

21.4 LITERATURE CITED

BRT (Biological Review Team). 2003. NOAA Fisheries Status Review. Preliminary conclusions regarding the updated status of listed ESUs of West Coast salmon and steelhead: Chinook Salmon ESUs. Available from NOAA Fisheries, NWFSC. Montlake, WA.

Chilcote, M. 1998. Conservation status of steelhead in Oregon. Information Reports Number 98-3. Oregon Department of Fish and Wildlife. Fish Division. Portland, Oregon. 108 p.

Firman, J. and M. Buckman. 2003. Work completed for compliance with the Biological Opinion for hatchery programs in the Willamette Basin, USACE funding: 2002-03. Addendum. Oregon Department of Fish and Wildlife. Corvallis.

Myers, J., C. Busack, D. Rawding, and A. Marshall. 2002. Identifying historical populations of chinook and chum salmon and steelhead within the Lower Columbia River and Upper Willamette River Evolutionarily Significant Units. Co-manager review draft. Willamette/Lower Columbia Technical Recovery Team. NOAA Fisheries Seattle, WA.

22.0 OREGON COAST COHO SALMON ESU

22.1 BACKGROUND

22.1.1 Description of the ESU

All naturally produced coho salmon are included as part of the Oregon Coast coho salmon evolutionarily significant unit (ESU). There are also seven hatchery stocks currently being propagated within the ESU. Of the seven, five were determined to be included in the Oregon

Table 22.3. List of preliminary natural populations of Oregon Coast coho salmon identified by the Oregon Coast coho TRT (Lawson *et al.* 2004) and associated hatchery stocks.

Preliminary TRT populations (potentially or functionally independent)	Hatchery program (included, not included in ESU)	Integrated or isolated program	Program Description	Program size (Max. release/yr)	Year initiated
Necanicum	none				
Nehalem	NF Nehalem (not included)	Isolated	Harvest	200,000	1966
Tillamook Bay	Trask (not included)	Isolated	Harvest	200,000	1916
Nestucca	none				
Salmon	Salmon (not included)	Isolated	Harvest	200,000	1976
Siletz	Salmon (not included)	Isolated	Harvest	50,000	
Yaquina	none				
Beaver	none				
Alsea	none				
Siuslaw	none				
Siltcoos	none				
Tahkenitch	none				
Lower Umpqua	Calapooya (included)	Integrated	Research (no more juvenile releases)	Adults returning through 2006	2001
Upper Umpqua	Cow (included)	Integrated	Harvest	60,000	1987
	Rock (included)	Integrated	Harvest	62,500	1920
Tenmile	none				
Coos Bay	Coos (included)	Integrated	Harvest	120,000	1981
Coquille	Coquille (included)	Integrated	Harvest	50,000	1979
Floras	none				
Sixes	none				
Summary: 19 functionally and potentially independent populations were designated by TRT. Five hatchery stocks included in the ESU. Three hatchery stocks not included in the ESU. Eight of the 19 populations have program influences. The total hatchery smolt production goal is 942,500 fish.					

Coast ESU (Table 22.1).

22.1.2 Status of the ESU

The BRT (2003) recommended a threatened listing for Oregon Coast coho salmon. There was concern regarding declines in productivity rates in recent years, with the 1994-1996 broodyears being the first time on record when coho did not replace themselves. Since 1999, with improved freshwater and ocean survival rates, there have been increases in abundance of the ESU, with substantial increases in the runs of the north coast rivers. The BRT also expressed concern about whether current habitat would be able to sustain coho populations when ocean survival decreases again in the future.

The BRT considered most, if not all, of the recent management changes for coho hatcheries in the ESU in their risk assessment of the ESU. They noted that many of the recent changes (e.g., elimination of some programs, reductions in hatchery fish releases, development of local broodstocks, marking of all fish) would presumably be positive for the conservation and recovery of natural populations. In the past, relatively high numbers of hatchery coho salmon were released throughout the Oregon Coast. The high numbers of hatchery fish presented significant genetic and ecological risks to the conservation of naturally produced fish in the ESU (Nickelson 2003).

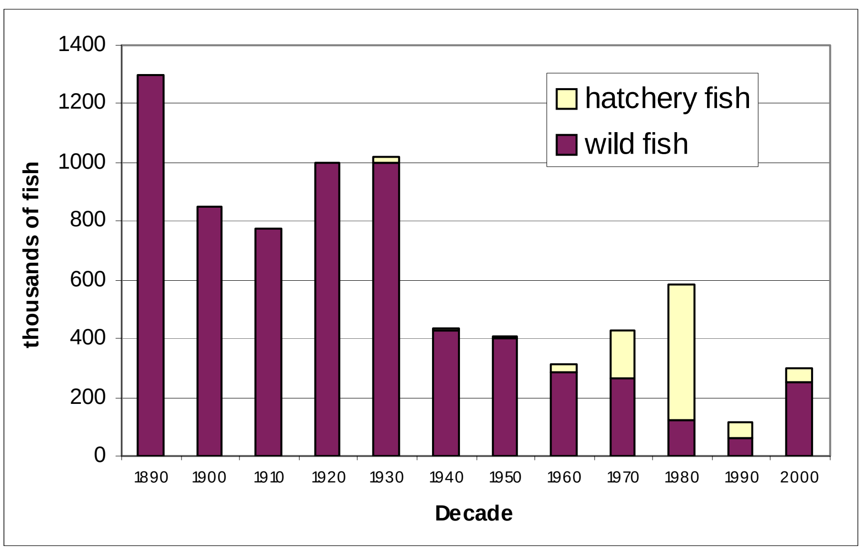

Figure 22.13. Estimated preharvest abundance of hatchery and wild coho salmon destined for the Oregon Coast ESU.

22.2 ASSESSMENT OF THE HATCHERY PROGRAM(S)

22.2.1 Nehalem

22.2.1.1 Program History

The current hatchery broodstock was founded from adult returns to the hatchery facility in the North Fork Nehalem and Fishhawk Creek (Nehalem basin). The current broodstock is likely a mixture of both the original North Fork Nehalem and Fishhawk wild coho stocks because of management practices. No natural coho salmon have been intentionally included in the broodstock since 1986. In recent years, the number of natural coho collected at the hatchery has been low; thus it is not likely that substantial numbers of natural fish have been included in the broodstock over the years. ODFW is not currently incorporating natural fish into the broodstock (ODFW Nehalem HGMP 2001). This broodstock is managed in isolation from the natural population.

Table 22.4 Total number of coho salmon returning to the Oregon Coast coho salmon ESU. Only hatchery stocks included in the ESU are shown.

Year	Estimated number of natural-origin spawners	Estimated number of hatchery-origin fish (ESU stocks) returning to facilities	Total number of fish included in the ESU
1990	21,044	9,947	30,991
1991	38,152	32,072	70,224
1992	42,539	21,383	63,922
1993	55,423	16,376	71,799
1994	44,480	11,083	55,563
1995	54,089	11,062	65,151
1996	74,275	17,963	92,238
1997	23,580	10,601	34,181
1998	31,988	15,860	47,848
1999	48,862	6,471	55,333
2000	69,281	14,690	83,971
2001	170,719	25,466	196,185
2002	257,508	12,585	270,093
2003	241,992	7,513	249,505
2004	more than 196,000	not available	>196,000

22.2.1.2 Similarity between Hatchery-origin and Natural-origin Fish

North Fork Nehalem hatchery fish cluster genetically with other stocks that are part of the Oregon Coast ESU (Weitkamp *et al.* 1995). Information has been collected recently on natural fish in the Nehalem basin as part of the Oregon Plan monitoring, although this information has not been assessed with respect to the hatchery fish. The current broodstock was founded from the local population, although natural fish have not been intentionally incorporated into the broodstock since 1986. It is possible there could be substantial differences between the hatchery stock and local population.

22.2.1.3 Program Design

The program is intended to provide fish solely for commercial and recreational harvest. All of the releases are adipose fin-clipped. Program fish are not being used to supplement natural spawning, and in recent years, hatchery fish on the spawning grounds in the Nehalem basin has been less than 10% of the spawners since 1998 (Figure 22.3; OPSW 2002). The current program releases fewer than 200,000 smolts annually (more than a 50% reduction from releases in the

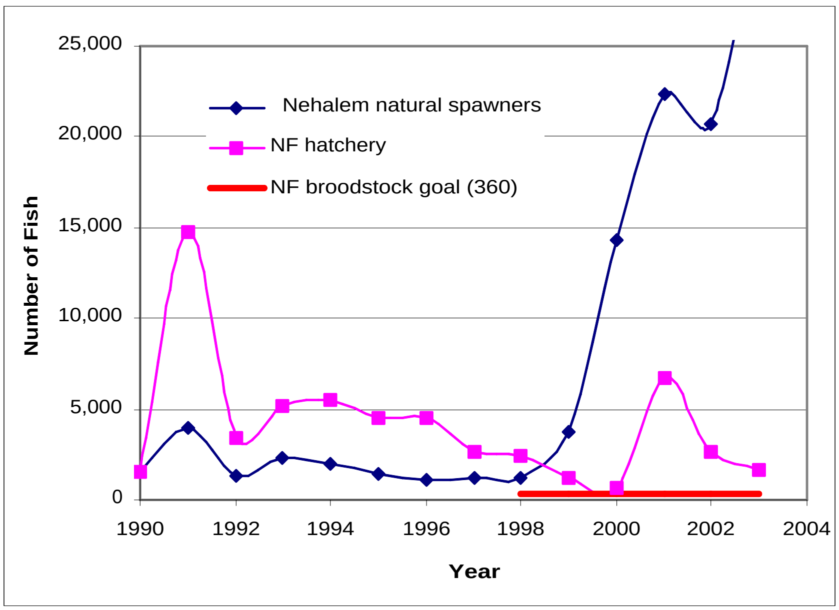

Figure 22.14. Estimated number of natural-origin spawners, number of coho salmon collected at hatchery facilities, and the recent broodstock goal for the program.

early 1990s).

22.2.1.4 Program Performance

The program has returned sufficient numbers of fish to the hatchery to meet broodstock needs every year since 1990 (Figure 22.2). The smolt-to-adult survival rate for this program has ranged from 0.55% to 4.60% for broodyears 1985 to 1996, with an average of approximately 2%

(ODFW Nehalem HGMP 2001). This program relies entirely on the State of Oregon for funding, which has been uncertain in recent years due to budget shortfalls.

22.2.1.5 VSP Effects

Abundance - From 1990 to 2003, the average number of natural fish spawning in the Nehalem basin was 7,700 fish (Figure 22.2; PFMC 2004). From 1970 to 2003, returns to the North Fork Nehalem hatchery facility have averaged more than 3,700 fish. In recent years, hatchery fish have made up less than 10% of the natural spawners in the Nehalem basin (OPSW 2002).

This hatchery program provides more fish returning to the North Fork Nehalem but does not provide benefits to natural spawning. The program is being managed to isolate hatchery fish from the natural population. No natural fish are intentionally incorporated into the broodstock.

Productivity - Productivity rates (recruits per spawner) have averaged more than one for the hatchery program (Figure 22.2). Since few hatchery fish are spawning in the wild, the hatchery program has little to no effect on the productivity rate of the naturally spawning population. Nickelson (2003) showed productivity of natural coho populations to be negatively affected by hatchery programs on the Oregon Coast. Large numbers of hatchery fish attracted predators in the lower rivers and estuaries, causing higher mortality of natural-origin fish than would occur without a hatchery program. These productivity risks caused by the hatchery program have been reduced in recent years due to substantial reductions in the number of hatchery fish released into the Nehalem basin (down 66% from Nickelson’s analysis).

Spatial Structure - Natural fish are widely distributed throughout the Nehalem basin. The hatchery facility is located on the North Fork Nehalem, a small tributary to the mainstem Nehalem River. An electric weir across the North Fork Nehalem at the hatchery that was in operation in the past may have adversely affected upstream migration of natural fish, thus changing the spawning distribution. The weir is no longer in operation. Hatchery fish are collected at the hatchery and upstream in a ladder trap at North Fork falls.

Diversity - Since few hatchery fish are spawning naturally, genetic introgression of hatchery fish into the natural population is presumed to be low. It is possible the hatchery fish have different life history characteristics than natural fish because the program is being managed in isolation (see above).

22.2.2 Tillamook Bay

22.2.2.1 Program History

The current broodstock has been collected from returns to hatchery traps in the Trask River since 1961. Prior to this, other stocks were imported into the hatchery program. No natural coho salmon have been intentionally included in the broodstock. In recent years, the number of natural coho collected at the hatchery has been low, so it is not likely substantial numbers of natural fish have been included into the broodstock over the years. ODFW is not currently incorporating natural fish into the broodstock (ODFW Trask HGMP 2001). This broodstock is managed in isolation from the natural population and is not included as part of the ESU.

22.2.2.2 Similarity between Hatchery-origin and Natural-origin Fish

Trask River hatchery fish cluster genetically with other stocks that are part of the Oregon Coast ESU (Weitkamp *et al.* 1995). Information has been collected recently on natural fish along the Oregon Coast as part of the Oregon Plan monitoring, although this information has not been assessed with respect to the hatchery fish. Since this hatchery stock was deemed not part of the ESU, there are likely significant differences between the hatchery stock and the local natural population.

22.2.2.3 Program Design

The program is intended to provide fish solely for commercial and recreational harvest. All of the releases are adipose fin-clipped. Program fish are not being used to supplement natural spawning, and since 1998, hatchery fish on the spawning grounds have made up less than 10% of the spawners (Figure 22.3; OPSW 2002). The current program releases fewer than 200,000 smolts annually. Releases were more than one million smolts in the 1980s and early 1990s.

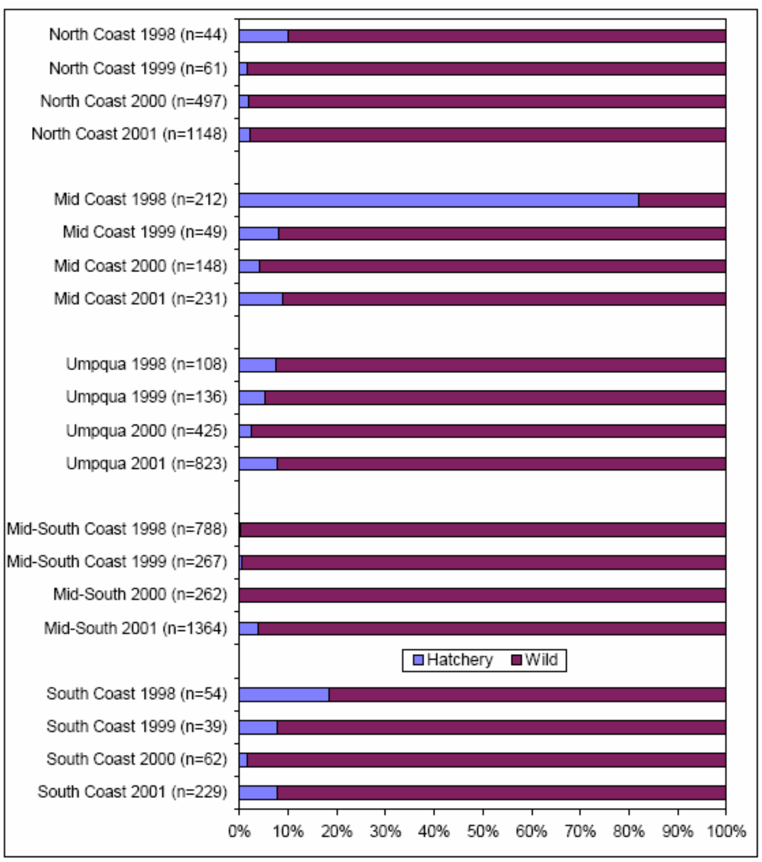

Figure 22.15. Proportion of hatchery and wild coho salmon estimated from spawning surveys. Taken from OPSW (2002).

22.2.2.4 Program Performance

The program has returned sufficient numbers of fish to the hatchery to meet broodstock needs every year since 1990 (Figure 22.4). The smolt-to-adult survival rate for this program has ranged from 0.47% to 2.96% for broodyears 1985 to 1996, with an average of approximately 1% (ODFW Trask HGMP 2001). This program relies entirely on the State of Oregon for funding, which has been uncertain in recent years due to budget shortfalls. In 2001, it was proposed that the program be terminated, but it has remained in place.

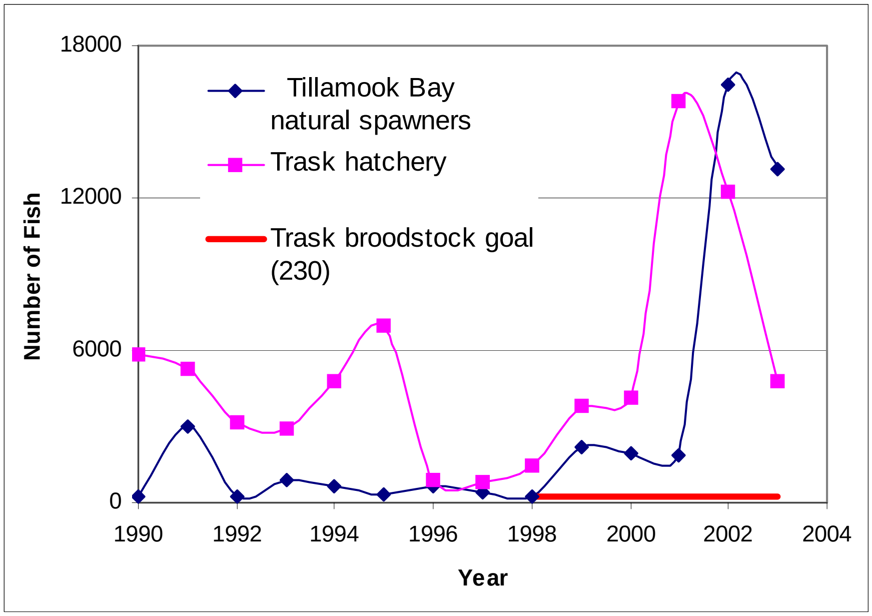

Figure 22.16. Estimated number of natural-origin coho spawners, number of coho salmon collected at the hatchery, and the current broodstock goal for the program.

22.2.2.5 VSP Effects

Abundance - From 1990 to 2003, the average number of natural fish spawning in the Tillamook Bay Basin (Miami, Kilchis, Wilson, Trask, and Tillamook rivers) was 2,900 (Figure 22.4; PFMC 2004). From 1970 to 2003, returns to the Trask hatchery averaged more than 4,400 fish. In recent years, hatchery fish have made up less than 10% of the natural spawners in the Tillamook Bay Basin (OPSW 2002). The program is being managed to isolate hatchery fish from the natural population. No natural fish are intentionally incorporated into the broodstock.

Productivity - Productivity rates (recruits per spawner) have averaged more than one for the hatchery program (Figure 22.4). Since few hatchery fish are spawning in the wild, the hatchery program has little to no effect on the productivity rate of the naturally spawning population.

Nickelson (2003) showed productivity of natural coho populations to be negatively affected by hatchery programs on the Oregon Coast. Large numbers of hatchery fish attracted predators in the lower rivers and estuaries, causing higher mortality of natural-origin fish than would occur without a hatchery program. These productivity risks caused by the hatchery program have been reduced in recent years due to substantial reductions in the number of hatchery fish released into the Trask basin (down 66% from Nickelson's analysis).

Spatial Structure - Natural fish have been widely distributed throughout the Tillamook Bay basin in recent years. The hatchery facility is located on the Trask River, one of the five tributaries to Tillamook Bay. No hatchery traps or weirs are known to adversely affect the spatial distribution of this population.

Diversity - Since few hatchery fish are spawning naturally, genetic introgression of hatchery fish into the natural population is presumed to be low. However, any hatchery fish spawning in the wild may pose a risk to the natural population because this hatchery stock is not part of the ESU. The hatchery stock has likely diverged from the local natural stock. Significant run timing differences between hatchery and natural fish have been observed in the past.

22.2.3 Salmon River Hatchery

22.2.3.1 Program History

The current broodstock has been collected from returns to the Salmon River Hatchery. Smolts from this broodstock are released into the Salmon and Siletz rivers. No natural coho salmon have been intentionally included in the broodstock. The program is being managed as an isolated harvest program. This hatchery stock is not included as part of the ESU.

22.2.3.2 Similarity between Hatchery-origin and Natural-origin Fish

Salmon River Hatchery stock is not included as part of the ESU, because the stock was likely diverged from natural stocks in the ESU. It is not known what life history differences may exist between hatchery fish and the local population. Hatchery fish have strayed substantially into natural habitat in the past and made up over 90% of the spawners in the 1990s (ODFW Salmon HGMP 2001). The Salmon River population has most of the natural spawners of hatchery origin in the ESU (OPSW 2002).

22.2.3.3 Program Design

The program is intended to provide fish solely for commercial and recreational harvest. All of the releases are adipose fin-clipped. Program fish are not being intentionally used to supplement natural spawning. However, uncontrollable numbers of hatchery fish have spawned naturally in the past (Figure 22.3; OPSW 2002). The current program releases fewer than 200,000 smolts annually.

22.2.3.4 Program Performance

The program has returned sufficient numbers of fish to the hatchery to meet broodstock needs every year since 1990 (Figure 22.5). The smolt-to-adult survival rate for this program has ranged from 0.50% to 1.51% for broodyears 1985 to 1996 (ODFW Salmon HGMP 2001). This program relies entirely on the State of Oregon for funding, which has been uncertain in recent years due to budget shortfalls. ODFW has stated that continuing this program is uncertain due to uncontrollable numbers of hatchery fish on the spawning grounds.

22.2.3.5 VSP Effects

Abundance - Natural fish returns to the Salmon River have been relatively low since 1990 (Figure 22.5). Hatchery fish spawners have made up over 90% of the natural spawning. This is of concern since the hatchery stock is not included in the ESU. It is unknown to what extent the natural population has been introgressed by Salmon River Hatchery stock. It is possible that offspring from naturally spawning hatchery fish make up most of the natural fish. The return of hatchery fish should decrease in the future, since releases have decreased from 1.5 million fish in the early 1990s to 200,000 fish currently.

The returns of hatchery fish back to Salmon River Hatchery have exceeded broodstock needs every year since 1990. There is little risk of not attaining enough fish for broodstock, especially when only 280 fish are needed (Figure 22.5).

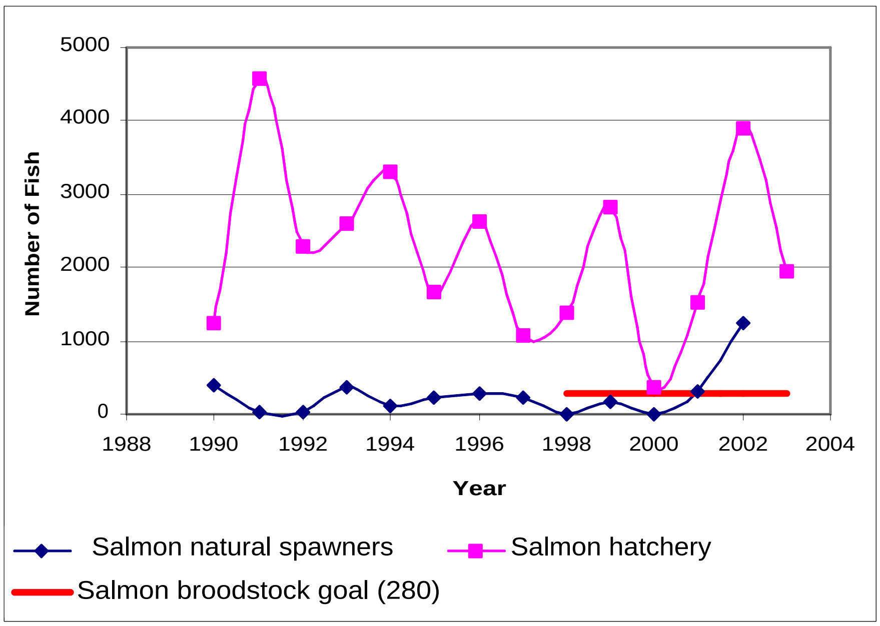

Figure 22.17. Estimated number of natural-origin coho spawners, number of coho salmon collected at the hatchery, and the current broodstock goal for the program.

Productivity - Productivity rates (recruits per spawner) have averaged more than one for the hatchery program (Figure 22.5). There is concern over the high percentage of natural spawners that are non-ESU hatchery fish. The extent hatchery fish spawning overlaps with natural fish spawning is not known. It is possible hatchery fish are decreasing productivity of the natural population from genetic introgression with natural fish or competition for limited resources.

Nickelson (2003) showed productivity of natural coho populations to be negatively affected by hatchery programs on the Oregon Coast. Large numbers of hatchery fish attracted predators in the lower rivers and estuaries, causing higher mortality of natural-origin fish than would occur without a hatchery program. These productivity risks of the hatchery program have been reduced in recent years by substantial reductions in the number of hatchery fish released into the Salmon basin (down 33% from Nickelson's analysis).

Spatial Structure - The hatchery facility and weirs are not presently affecting the spatial structure of the natural population. An electric weir was used in the past to shunt fish into the hatchery for broodstock, but it is no longer in operation. Hatchery fish straying into the wild is high and likely results in significant genetic introgression with the few naturally-produced fish returning to the basin.

Diversity - It is likely the hatchery program has adversely affected the life history diversity that existed historically in this population. The high percentage of hatchery fish on the spawning grounds of a non-ESU stock likely has changed life history traits of the natural population. Hatchery fish run timing is significantly earlier than for natural fish.

22.2.4 Siletz Hatchery

22.2.4.1 Broodstock History

The current program in the Siletz releases coho salmon smolts from broodstock collected in the Salmon River. Prior to 1986, coho salmon were collected at Siletz Hatchery. The Salmon River stock is not included as part of the ESU. The broodstock is isolated from the natural population in the Salmon River.

22.2.4.2 Similarity between Hatchery-origin and Natural-origin Fish

See Salmon River description above.

22.2.4.3 Program Design

The purpose of this program is to provide fish for recreational and Tribal harvest. Total releases of coho smolts are currently 50,000 fish. All fish are adipose fin-clipped. Hatchery fish made up most of the natural spawners in the basin when large numbers of hatchery fish were released in the Siletz River. It is expected a few hundred hatchery fish will return under the current smolt release (ODFW Siletz HGMP 2001). This should result in 10% of the spawning population being hatchery fish (Figure 22.6).

22.2.4.4 Program Performance

See Salmon River above.

22.2.4.5 VSP Effects

Abundance - The current program should result in only a few hundred fish returning to the Siletz River. Recent returns of natural fish have numbered in the thousands of fish, with the estimated number of spawners in 2003 being 10,000 natural fish (Figure 22.5). There appears to be little benefit of the hatchery program to the abundance of the Siletz population.

Productivity - Given the relatively low number of fish released in the Siletz basin, it is likely the program would not have a significant effect on the productivity of the population. However, if even a few hatchery fish spawn with natural fish, there is a potential for decreased productivity, since hatchery fish are diverged from the natural population in the ESU.

Spatial Structure – There is little to no effect of hatchery facilities on the Siletz population is anticipated. Broodstock are collected out-of-basin in the Salmon River.

Diversity – There is little to no effect on the natural diversity of the Siletz population is likely, since few hatchery fish are interacting with natural fish. Release numbers are relatively low.

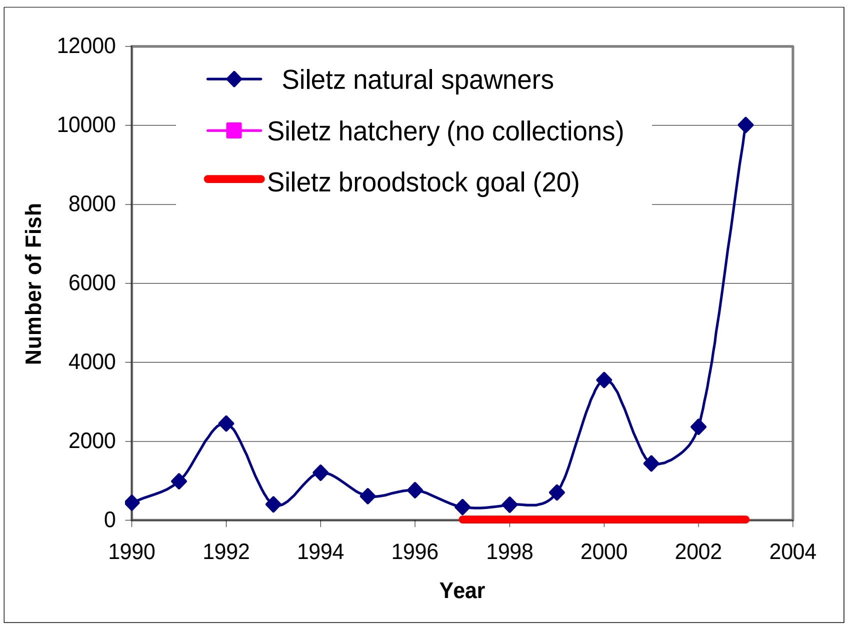

Figure 22.18. Estimated number of natural-origin coho spawners, number of coho salmon collected at the hatchery, and the current broodstock goal for the program.

22.2.5 Upper Umpqua

22.2.5.1 Program History

There are two conventional hatchery programs in the Upper Umpqua population. The Cow Creek program collects broodstock from returns to the base of Galesville Dam (located on Cow Creek in the South Umpqua basin). The Rock Creek program collects broodstock at Winchester Dam and from returns back to Rock Creek Hatchery (North Umpqua River basin). Both programs have incorporated natural fish into the broodstocks recently. The management goal is for at least 50% of the broodstock to comprise natural fish (ODFW Umpqua HGMP 2003).

Another coho hatchery stock exists in the Umpqua Basin- the Calapooya wild coho broodstock (#509). This stock is associated with a coho pedigree research study to evaluate the success of different hatchery and wild crosses. Fish were collected for broodstock from 2001 through 2003. This program is no longer releasing fish, but returning adults from this program will occur through 2006. The Calapooya River (where the adults return) is a tributary to the mainstem Umpqua River (Lower Umpqua). Broodstock was founded from the local population. Since this program is a research program and no longer is releasing fish, the program is not assessed below.

22.2.5.2 Similarity between Hatchery-origin and Natural-origin Fish

Genetic analyses indicate that both hatchery stocks cluster with other coho stocks in the Umpqua basin and the Oregon Coast ESU (Weitkamp *et al.* 1995; Lawson *et al.* 2004). It is likely the existing hatchery stocks show some resemblance to their respective natural runs, since the management goal is for at least 50% of the broodstock to comprise natural fish.

22.2.5.3 Program Design

Both programs are designed to provide fish for harvest. The Cow Creek program, partially funded by Douglas County to mitigate for fishery losses associated with Galesville Dam, releases 60,000 smolts annually. The Rock Creek program is funded entirely by the State of Oregon and currently releases 62,500 fish. The Rock Creek program also outplants coho fry into tributaries of the mainstem Umpqua River to supplement natural production (approximately 400,000 fry per year).

22.2.5.4 Program Performance

The programs have returned sufficient numbers of fish to the hatchery collection facilities to meet broodstock needs every year since 1990 (Figure 22.7). The smolt-to-adult survival rate for the Rock Creek program has ranged from 0.44% to 3.58% for brood years 1985 to 1996, with an average of approximately 1% (ODFW Umpqua HGMP 2003). It is expected the Cow Creek program would have similar survival rates. The number of hatchery fish on the spawning grounds throughout the Umpqua Basin in recent years has been less than 10% (Figure 22.3; OPSW 2002). However, the North Umpqua Basin is not surveyed as part of the Stratified Random Sampling survey done by ODFW. Counts of hatchery and natural fish are available at Winchester Dam. Hatchery fish have outnumbered natural fish at Winchester Dam since 1982 (ODFW Umpqua HGMP 2003). It is not known how many of these hatchery fish end up on the spawning grounds. Douglas County funds the Cow Creek program as mitigation for Galesville Dam. Continued funding is certain. Funding for the Rock Creek program has been uncertain in recent years due to Oregon budget shortfalls. This program was proposed for elimination in 2001 but is currently still in operation.

22.2.5.5 VSP Effects

Abundance - Natural fish spawning throughout the Umpqua basin increased substantially from 2001 through 2003 compared to the 1990s (Figure 22.7). However, given the estimated number of miles available for coho spawning in the Umpqua basin (1,083 miles), this area had the lowest density of spawners in the ESU in 2003 (PFMC 2004). Adipose fin-clipped hatchery fish have made up less than 10% of the natural spawners in the South Umpqua and main Umpqua basins in recent years (ODFW Corvallis research Web site May, 2004 http://oregonstate.edu/Dept/ODFW/). The North Umpqua basin is not surveyed as part of the coast-wide spawning surveys, so estimates of the number of hatchery fish spawning naturally are not available. The Rock Creek program also releases approximately 400,000 unfed fry into mainstem Umpqua tributaries for supplementation. Since these fish are not adipose fin-clipped, it is unknown what contribution these program fish are having on natural spawning.

Since hatchery coho salmon releases have been reduced in the Umpqua basin in recent years, and the number of hatchery fish spawning naturally has also decreased, the programs are not contributing much to the abundance of naturally spawning fish. The exception is the unfed fry program, but the number of adult spawners from this program is unknown.

The Cow Creek and Rock Creek hatchery programs have returned sufficient numbers of fish to exceed broodstock needs (Figure 22.7). Both programs need a total of approximately 920 fish for broodstock. The average number of hatchery fish crossing Winchester Dam on the North Umpqua River has been 6,000 fish each year from 1990 to 2002 (Figure 22.7). There appears to be little risk of not attaining sufficient returns for broodstock under the current production levels.

Both of these programs have incorporated natural fish into the broodstock in recent years. Since the hatchery stocks are integrated with the natural population, these programs provide a genetic reserve that could be used for recovery efforts in case the natural population decreases to very low abundances. The Cow Creek stock also likely resembles the remnant run of coho salmon that was blocked by the construction of Galesville Dam on Cow Creek, a tributary to the South Umpqua River.

Productivity - It is not known what effects the hatchery programs may be having on the productivity of the lower Umpqua and upper Umpqua populations. Information is lacking on the proportion of hatchery fish on the spawning grounds in the North Umpqua basin and adult returns from the unfed fry releases.

Spatial Structure - Rock Creek Hatchery, located on a tributary of the lower North Umpqua River is the only hatchery facility currently in operation in the Umpqua basin. Other collection traps are distributed in other areas, but these traps are associated with other programs (e.g., dams). The water intake structure and fish ladder at Rock Creek Hatchery inhibits upstream migration of coho salmon. Some coho salmon do migrate upstream, but passage conditions at the structure are poor. Approximately 10 to 20 miles of coho salmon habitat is upstream of the ladder.

Diversity - It is not clear what effects the hatchery programs may be having on the diversity of the natural populations. Large-scale releases of unfed fry from the North Umpqua River stock into mainstem Umpqua tributaries are of particular concern. These hatchery fish may out-compete the naturally produced juveniles co-occurring in the streams, especially given the unnaturally high densities of stocked fry.

The potential genetic effects from hatchery fish spawning in the wild are likely to be low in the South Umpqua basin, since few hatchery fish have been observed recently (Figure 22.3; ODFW Corvallis research Web site May, 2004 http://oregonstate.edu/Dept/ODFW/). In the mainstem

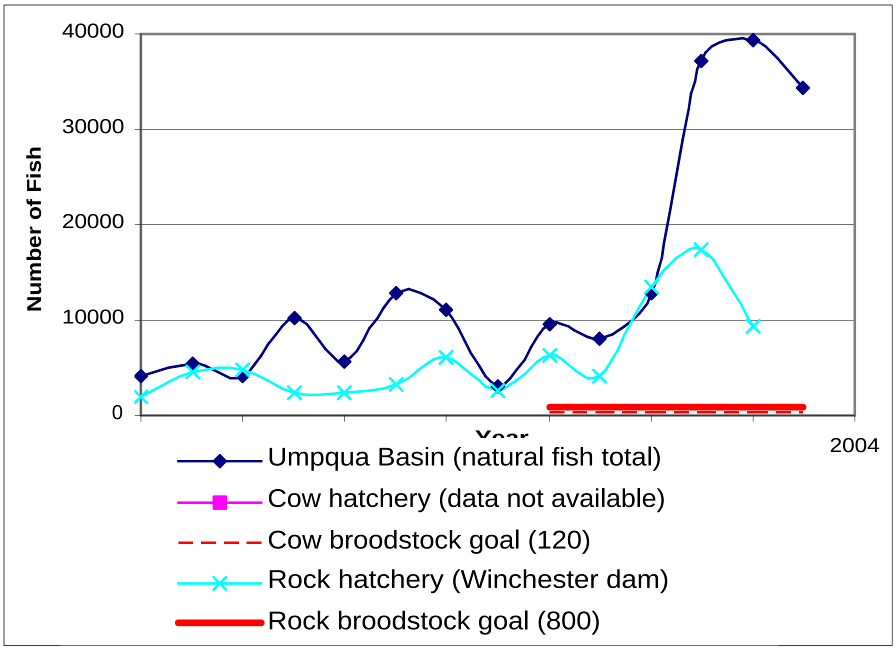

Figure 22.19. Estimated number of natural-origin spawners, number of coho salmon collected at the hatchery, and the current broodstock goal for the program.

Umpqua and North Umpqua, the extent of natural spawning by hatchery fish is unknown.

22.2.6 Coos Bay

22.2.6.1 Program History

The current hatchery program collects broodstock from local returns to the Coos basin. The management goal is for at least 30% of the broodstock to be made up of natural fish (ODFW Coos HGMP 2001). This hatchery stock is integrated with the local natural population and is included as part of the ESU.

22.2.6.2 Similarity between Hatchery-origin and Natural-origin Fish

The hatchery stock clusters genetically with other coho stocks in the ESU (Weitkamp *et al.* 1995; Lawson *et al.* 2004). It is likely the existing hatchery stock shows some resemblance to the natural run, since the management goal is for 30% of the broodstock to be made up of natural fish.

22.2.6.3 Program Design

The program is designed to provide fish for harvest. Coho salmon smolts (120,000) are released into Isthmuth Slough (a terminal fishery area with little natural production), so that hatchery fish can be targeted with minimal effects on other adjacent natural runs.

22.2.6.4 Program Performance

The programs have returned sufficient numbers of fish to the hatchery collection facilities to meet broodstock needs every year since 1990 (Figure 22.8). The smolt-to-adult survival rates for the Coos program has ranged from 0.26% to 6.67% for broodyears 1985 to 1996, with an annual average of approximately 2% (ODFW Coos HGMP 2001). The number of hatchery fish on the spawning grounds throughout the Coos basin in recent years has been less than 10% (OPSW 2002). The State of Oregon funds this program, and funding has been uncertain due to recent budget shortfalls.

22.2.6.5 VSP Effects

Abundance - The number of natural fish spawning throughout the Coos basin has improved in recent years (Figure 22.8). Spawning surveys have shown hatchery fish to represent less than 10% of the spawning population (Figure 22.3). The releases of hatchery fish in the Coos basin are designed to return fish to a terminal area where little natural production occurs so that natural fish can be avoided. It is unknown if the unharvested hatchery returns stray to other areas and spawn, or if their spawning success is poor in the terminal area.

Sufficient numbers of broodstock are collected every year for this program, mainly because natural fish are collected from traps operated throughout the basin. Since natural fish have been incorporated into the broodstock on a regular basis, the program could be considered a genetic reserve used for recovery efforts if the natural population were to collapse. However, there are concerns whether this program would be an appropriate reserve, given the small size of the program (see below).

Productivity - Given the relatively low number of fish released in the Coos basin, it is likely the program would not have a significant effect on the productivity of the population, especially given the high number of natural spawners (over 30,000 in 2001-2003; Figure 22.8).

Spatial Structure - Hatchery facilities located in the Coos basin have little to no effect on the spatial structure of the natural population. Several satellite trapping facilities are present in the basin, but they are only operated periodically to collect broodstock. Juvenile hatchery fish are reared at other hatchery facilities.

Diversity - The hatchery program incorporates natural coho into the broodstock on a regular basis. The intent is to collect broodstock throughout the breadth of the natural coho run. However, since only 168 fish are needed for broodstock, it is not known if the program adequately reflects the diversity of the natural run (which has exceeded 30,000 fish in recent years). It seems possible that the program might only represent some portions of the natural run, at best.

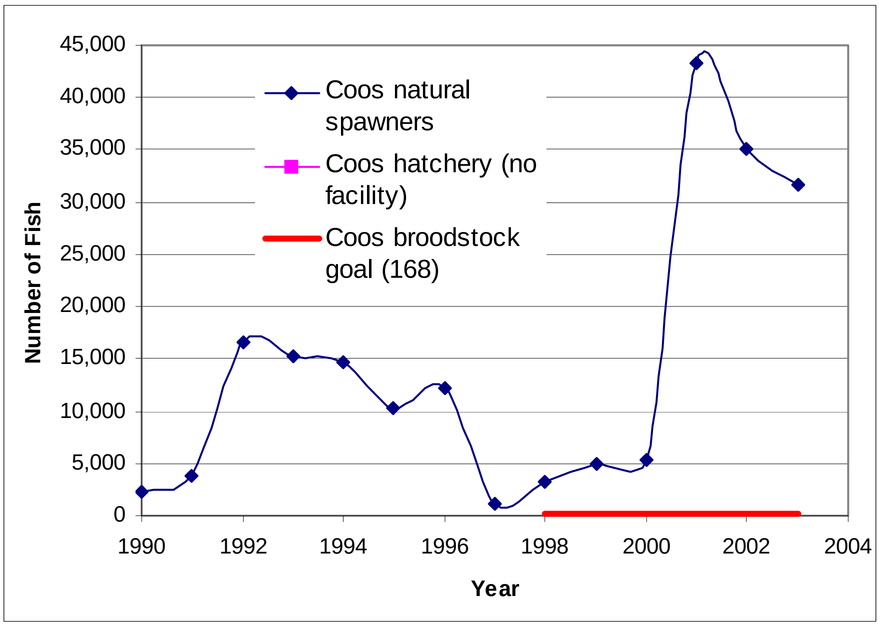

Figure 22.20. Estimated number of natural-origin coho spawners, number of coho salmon collected at the hatchery, and the current broodstock goal for the program.

22.2.7 Coquille

22.2.7.1 Broodstock History

The current hatchery program collects broodstock from local returns to the Coquille basin. The management goal is for at least 30% of the broodstock to be made up of natural fish (ODFW Coquille HGMP 2001). This hatchery stock is integrated with the local natural population and is included as part of the ESU.

22.2.7.2 Similarity between Hatchery-origin and Natural-origin Fish

Specific genetic information for this hatchery stock is not available. It is likely the existing hatchery stock shows some resemblance to the natural run, since the management goal is for at least 30% of the broodstock to be made up of natural fish.

22.2.7.3 Program Design

The program is designed to provide fish for harvest. Coho salmon smolts (50,000) are released into two small tributaries near the estuary. All of the releases are adipose fin-clipped. Hatchery fish have represented less than 10% of the spawners in the Coquille basin in recent years (OPSW 2002).

22.2.7.3 VSP Effects

The program is designed to provide fish for harvest. Coho salmon smolts (50,000) are released into two small tributaries near the estuary. All of the releases are adipose fin-clipped. Hatchery fish have represented less than 10% of the spawners in the Coquille basin in recent years (OPSW 2002).

22.2.7.4 Program Performance

The programs have returned sufficient numbers of fish to the hatchery collection facilities to meet broodstock needs every year since 1990 (Figure 22.9). The smolt-to-adult survival rate for the Coquille program has ranged from 0.04% to 3.37% for broodyears 1985 to 1996, with an average of approximately 0.75% (ODFW Coquille HGMP 2001). The number of hatchery fish on the spawning grounds throughout the Coquille basin in recent years has been less than 10% (OPSW 2002). The State of Oregon funds this program, and funding has been uncertain due to recent budget shortfalls.

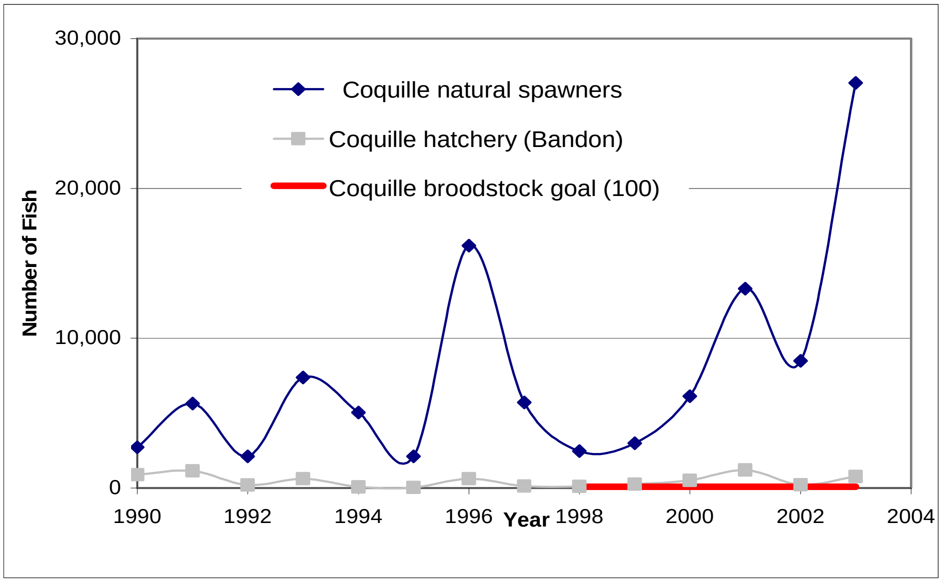

Figure 22.21. Estimated number of natural-origin coho spawners, number of coho salmon collected at the hatchery, and the current broodstock goal for the program.

22.2.7.5 VSP Effects

Abundance - The number of natural fish spawning throughout the Coquille basin has improved in recent years (Figure 22.9). Spawning surveys have shown hatchery fish to represent less than 10% of the spawning population (Figure 22.3). The total release of hatchery coho in the Coquille Basin is relatively low (50,000 fish currently). Given these low numbers, adult returns are also low compared to returns of natural fish. The hatchery program is providing little benefit to the abundance of the naturally spawning component of the population.

Sufficient numbers of broodstock are collected annually to maintain this program under the current production goals. Hatchery fish are collected from returns to Bandon Hatchery. Natural coho are also collected from various trapping facilities throughout the basin and incorporated into the hatchery broodstock.

Productivity - Given the relatively low number of fish released in the Coquille basin, it is likely the program would not have a significant effect on the productivity of the population, especially given the high number of natural spawners (Figure 22.9).

Spatial Structure - Bandon Hatchery is located on a small tributary to the lower Coquille River. The hatchery has an impassable weir that diverts fish returns to the hatchery (ODFW Coquille HGMP 2001). The spawning habitat above the weir represents a small fraction of the habitat available for coho salmon in the basin (probably less than 1%).

Diversity - The hatchery program incorporates natural coho into the broodstock on a regular basis. The intent is to collect broodstock throughout the breadth of the natural coho run. However, since only 100 fish are needed for broodstock, it is not known if the program adequately reflects the diversity of the natural run (which has exceeded 10,000 fish in recent years). It is possible that the program only represents certain portions of the natural run, at best.

22.3 CONCLUSION

Existing Status: Threatened
BRT Finding: Threatened
Recommendation: Threatened

22.3.1 ESU Overview

22.3.1.1 History of Populations

The Oregon Coast Technical Recovery Team identified 67 historic populations within the Oregon Coast coho salmon ESU (Lawson *et al.* 2004; co-manager review draft). Nineteen of the 67 populations were classified as Functionally or Potentially Independent Populations. The remaining 48 populations were classified as Dependent Populations that probably experienced periodic extinction and re-colonization events on a timeframe of 100 to 1000 years.

22.3.1.1 Association between Natural Populations and Artificial Propagation

Natural populations "with minimal genetic contribution from hatchery fish" – Of the 19 Functionally Independent and Potentially Independent Populations classified in the ESU, 12 have minimal genetic contribution from hatchery fish, because no programs are currently being operated within the geographic boundaries of these natural populations. Of the remaining seven populations, in the last few years hatchery fish have made up less than 10% of the natural spawners in all of the populations except one (Salmon River).

Natural[i] populations "that are stable or increasing, are spawning in the wild, and have adequate spawning and rearing habitat" [j] – All of the Functionally Independent and Potentially Independent Populations have increasing trends in abundance over the last five years. However, the long-term trends over the last 100 years are negative for all of these natural populations. The BRT (2003) expressed concern about whether current habitat conditions within the ESU could sustain the coho populations through another episode of poor ocean survival.

Mixed (Integrated Programs[k]) – Rock, Cow, Coos, Coquille hatchery stocks.

Hatchery (Isolated[l]) – North Fork Nehalem, Trask, and Salmon hatchery stocks.

---

[i] See HLP for definition of natural, mixed and hatchery populations

[j] HLP Point 3

[k] Integrated programs follow practices designed to promote and protect genetic diversity and only use fish from the same local population for broodstock (both natural-origin fish, whenever possible, and hatchery-origin fish derived from the same local population and included in the ESU). Programs operated to protect genetic diversity in the absence of natural-origin fish (e.g., captive broodstock programs and the reintroduction of fish into vacant habitat) are considered "integrated".

[l] Isolated programs do not follow practices designed to promote or protect genetic diversity. Fish that are reproductively isolated are

22.3.2 Summary of ESU Viability

22.3.2.1 Abundance

The lowest risk factor for this ESU was in the abundance category (BRT 2003). The number of natural-origin coho salmon spawners increased substantially from 2001 through 2003 compared to the lowest counts on record in the 1990s. Since the number of hatchery coho programs and the total number of hatchery fish released has been reduced substantially in recent years, hatchery fish have made up less than 10% of the fish on the spawning grounds since 1999.

22.3.2.2 Productivity

The highest risk factor for this ESU is low productivity (BRT 2003). For the first time on record since 1950, the 1997-1999 returns of coho salmon did not replace themselves. Productivity rates in subsequent broodyears have increased due to increased survival rates. The long-term productivity rate trend for the ESU is negative. The BRT (2003) expressed concern whether coho salmon populations would be able to sustain themselves under current habitat conditions during the next cycle of poor ocean conditions.

In recent years, since hatchery fish make up less than 10% of the natural spawners, and hatchery smolt production goals are not likely to increase in the near future, hatchery fish are not likely to increase the productivity of coho salmon in the wild. There are no known data indicating hatchery programs have changed ESU productivity.

22.3.2.3 Spatial Structure

In recent years, natural-origin coho salmon have been widely distributed and spawning throughout the ESU. Hatchery fish are not being used to reintroduce fish into unoccupied habitat. Operation of the hatchery facilities has a negligible effect on the overall distribution and migration of juvenile and adult coho salmon in the ESU.

22.3.2.4 Diversity

Integrated propagation programs in the Coquille, Coos, and Upper Umpqua basins are being managed as wild broodstocks that resemble natural fish to the extent possible. The N. Nehalem program is an isolated program that has not incorporated natural fish into the broodstock on a regular basis. There may be localized detrimental effects of the hatchery programs depending on the location and extent to which hatchery fish are spawning naturally.

22.3.3 Artificial Propagation Record

22.3.3.1 Experience with Integrated Programs

The Coquille, Coos, Rock, and Cow hatchery stocks are integrated with natural origin coho

---

more likely to diverge genetically from natural populations included in the ESU and to be excluded themselves from the ESU.

salmon. All of these programs have been in operation for more than a decade.

22.3.3.2 Data on Whether Integrated Programs Are Self-sustaining

The Coquille, Coos, Rock, and Cow hatchery stocks have exceeded broodstock goals nearly every year since the programs were initiated. Spawner-to-spawner replacement rates have averaged more than one since the programs have been in operation.

22.3.3.3 Certainty that Integrated Programs will Continue to Operate

All of the integrated programs are funded by the State of Oregon, with the exception of the Cow Hatchery program. In recent years, continuation of these programs has been uncertain due to budget shortfalls. Monitoring and evaluation supporting effective adaptive management are strengths of these propagation programs.

22.3.4 Summary of Overall Extinction Risk Faced by the ESU

Recent improvements in spawner abundance from 2001 through 2003 have decreased the extinction risk of the ESU. However, recent abundances are still probably less than 25% of historical abundances (BRT 2003). The primary concern is declining productivity throughout the ESU. If habitat conditions continue to degrade, it is doubtful the ESU would be able to sustain itself during poor survival episodes in the future. The current hatchery programs are providing some benefit to the abundance in the southern areas of the ESU (Coquille, Coos, and Upper Umpqua population). The majority of the areas do not have any associated hatchery programs.

22.4 LITERATURE CITED

BRT (Biological Review Team). 2003. Preliminary conclusions regarding the updated status of listed ESUs of West Coast salmon and steelhead. Draft report. Northwest Fisheries Science Center, Seattle, Washington; Southwest Fisheries Science Center, Santa Cruz Laboratory, Santa Cruz, California. February 2003.

Lawson, P. W., E. Bjorkstedt, C. Huntington, T. Nickelson, G. L. Reeves, H. A. Stout, and T. C. Wainwright. 2004. Identification of historical populations of coho salmon (Oncorhynchus kisutch) in the Oregon Coast Evolutionarily Significant Unit. Co-manager’s Draft ONCC-TRT. NOAA/NMFS/NWFSC. 123 p.

Nickelson, T. 2003. The influence of hatchery coho salmon (Oncorhynchus kisutch) on the productivity of wild coho salmon populations in Oregon coastal basins. Canadian Journal of Fisheries and Aquatic Sciences 60:1050-1056.

ODFW (Oregon Department of Fish and Wildlife). 2001. Nehalem Hatchery Coho Salmon Hatchery and Genetic Management Plan. Draft. Fish Division. Salem.

ODFW (Oregon Department of Fish and Wildlife). 2001. Trask Hatchery Coho Salmon Hatchery and Genetic Management Plan. Draft. Fish Division. Salem.

ODFW (Oregon Department of Fish and Wildlife). 2001. Salmon Hatchery Coho Salmon Hatchery and Genetic Management Plan. Draft. Fish Division. Salem.

ODFW (Oregon Department of Fish and Wildlife). 2001. Siletz Hatchery Coho Salmon Hatchery and Genetic Management Plan. Draft. Fish Division. Salem.

ODFW (Oregon Department of Fish and Wildlife). 2001. Coquille River Coho Program Hatchery and Genetic Management Plan. Draft. Fish Division. Salem.

ODFW (Oregon Department of Fish and Wildlife). 2001. Coos River Coho Program Hatchery and Genetic Management Plan. Draft. Fish Division. Salem.

ODFW (Oregon Department of Fish and Wildlife). 2003. Umpqua River Basin Coho Program Hatchery and Genetic Management Plan. Draft. Fish Division. Salem.

OPSW (Oregon Plan for Salmon and Watersheds). 2002. Oregon Plan for Salmon and Watersheds Monitoring Report OPSW-ODFW-2002-3. Oregon Department of Fish and Wildlife. Corvallis, OR.

PFMC (Pacific Fishery Management Council). 2004. Preseason Report I Stock Abundance Analysis for 2004 Ocean Salmon Fisheries. (Document prepared for the Council and its advisory entities.) Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, Oregon 97220-1384.

Weitkamp, L. A., T. C. Wainwright, G. J. Bryant, G. B. Milner, D. J. Teel, R. G. Kope, and R. S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. NOAA-NWFSC-24.

23.0 SOUTHERN OREGON NORTHERN CALIFORNIA COAST COHO ESU

23.1 BACKGROUND

23.1.1 Description of the ESU

The Southern Oregon Northern California Coast Coho (SONCC) evolutionarily significant unit (ESU) extends from Cape Blanco in southern Oregon to Punta Gorda in northern California and includes all naturally spawned populations of coho salmon in accessible river and tributary reaches within the ESU. Oregon stocks included in the ESU are from the Rogue River basin and Elk River. California stocks included in the ESU are from the Klamath, Trinity, and Eel river basins; the Smith and Mad rivers; and Redwood Creek. Historically the ESU may have included one or more populations originating in areas above the Lost Creek, Applegate, Elk Creek, Iron Gate, Copco, Trinity River and Lewiston dams. Also included in the ESU are the artificially propagated coho salmon stocks (and their progeny) from the Cole M. Rivers Hatchery, Iron Gate Hatchery, and Trinity River Hatchery. There are currently no other anadromous hatchery coho salmon propagated within the SONCC ESU.

23.1.2 Status of the ESU

The SONCC ESU was listed as a threatened species on May 6, 1997 (62 FR 24588), due to the depressed numbers of naturally produced coho salmon, the number of environmental and human-caused threats to the species including hatchery impacts, and the lack of adequate regulatory protection to conserve the ESU. Historical abundance for the SONCC was estimated to have been between 150,000 and 400,000 fish, reduced to 10,000 by 1995. Weitkamp *et al.* (1995) noted that run estimates taken from seine surveys at the mouth of the Rogue River had increased from 450 to 19,200 naturally produced coho salmon adults between 1979 and 1991, while California populations were less than 6% of their 1940 abundance and had declined by 70% since the 1960s (CDFG 1994). Annual spawning escapement to the Klamath River system in 1983 was estimated to range from 15,400 to 20,000 by the U.S. Commission for Fish and Fisheries in 1892. These estimates, which include hatchery stocks, were less than 6% of their abundance in the 1940s (CDFG 1994). Adult returns to the Klamath River basin reflect an 88% decline from 1965 to 1991 (CDFG 1965; Brown *et al*.1994). Historically, the majority of coho salmon spawning took place in the Scott, Shasta, and Salmon rivers and numerous other tributaries (Kruzic and Bryant 1998). The Shasta River fish facility has documented 291 coho salmon in 2001 and 86 in 2002, while coho salmon juveniles have been captured in Scott River mainstem trapping efforts (CDFG 2002b). Coho are reportedly scarce in the Salmon River (Elder *et al*. 2002). On an annual basis, the estimated percentage of historical California coho salmon streams in the SONCC for which coho salmon presence was detected has fluctuated between 36% and 61% for brood years 1986 through 2000 (BRT 2003). Despite the pattern of variable occupancy rates, there has been no extreme change in the percentage of coho salmon streams occupied from the late 1980s to the present (BRT 2003). Recent attention has been focused on possible effects of the large hatchery program on the sustainability of natural populations in the Rogue and Klamath/Trinity river basins. Other factors identified by the BRT as risks to the ESU include the apparent frequency of local extinctions; long-term downward trends in coho salmon viability; degraded habitat and subsequent reduction in carrying capacity; competition, introgression, and domestication effects from hatchery fish; little or no infusion of wild genes into the hatchery programs; out-of-basin straying by large numbers of hatchery fish; and historical and reciprocal transfers of inter-basin stocks. In its assessment of the ESU, two-thirds of the BRT voted that the ESU is "likely to be endangered," and a majority of the remaining members voted that the ESU is in "danger of extinction" (BRT 2003). The BRT expressed serious concerns over ESU abundance, productivity, and spatial structure and substantial concerns about ESU diversity.

23.2 ASSESSMENT OF HATCHERY PROGRAMS

The ESU includes a number of extant populations. Additionally, the coho salmon (and their progeny) from the artificially propagated stocks at Cole M. Rivers Hatchery, Iron Gate Hatchery, and Trinity River Hatchery programs are considered to be part of the listed SONCC ESU. There are currently no other anadromous hatchery coho salmon being propagated within the SONCC ESU. The following section presents a summary of the broodstock/program history, similarity between hatchery-origin and natural-origin fish, program design, and program performance of these artificial propagation programs (Table 23.1).

Table 23.1. Artificial Propagation Programs which release coho salmon within the geographical area of the SONCC ESU.

HGMP Name	Program Type and Purpose	ESU Status *	Program Description	Program Size (Max. release/yr)	Years in Operation
Cole Rivers Hatchery	Integrated	In	Yearling smolt	200,000	30
Iron Gate Hatchery	Integrated	In	Yearling smolt	75,000	39
Trinity River Hatchery	Integrated	In	Yearling smolt	500,000	44

* SSHAG (2003) recommendations.

23.2.1 Iron Gate Hatchery (Klamath River)

Klamath River coho salmon had once ascended Klamath River and its tributaries to Klamath Falls, Oregon, but they are now restricted by Iron Gate Dam (Israel and Williamson 2003). The Klamath Basin coho also has shown great declines in abundance since the middle of the 20th century. Although no reliable population estimates are available, direct observation of spawning runs indicates that native coho are present only in small numbers. The Klamath River coho salmon population is affected by the Iron Gate Hatchery (IGH) artificial propagation program, which releases its annual coho salmon production within the Klamath River basin. The IGH program integrates local, native fish into its broodstock and has exclusively used fish returning to the hatchery as of 1977. The IGH program is considered part of the SONCC ESU.

23.2.1.1 Program History

Artificial propagation at IGH began in 1965 as mitigation for Iron Gate Dam. The coho salmon program is funded by Pacific Power & Light Company (PacifiCorps) and is managed by the California Department of Fish and Game (CDFG). The program was designed to supplement Klamath River coho salmon with the estimated number of fish lost from natural production through habitat impacts from the construction and operation of the Klamath Hydroelectric Project (KHP) and loss of 16 miles of spawning gravel between Copco Dam and Iron Gate Dam (SHAGG 2003; Israel and Williamson 2003).

There is no developed monitoring and evaluation plan to provide feedback for adaptive management of the IGH coho salmon program. The number of coho salmon returning to the Iron Gate Hatchery are highly variable and have ranged from no fish in 1964 to 2,893 fish in 1987 (K. Rushton, CDFG, personal communication). A Hatchery and Genetic Management Plan (HGMP) will be developed for the coho salmon hatchery program in conjunction with an ESA consultation on the Klamath Hydroelectric Project (Project). Impacts from the hatchery program on the natural population will result in program changes.

IGH broodstock was originally founded from Trinity River fish, Cascade River fish, and an unidentified stock. Only Klamath River stocks have been released at the hatchery since 1977, and some local, native fish are included in the program broodstock. The Klamath River itself has been planted with hatchery stocks from the Trinity River, Darrah Springs, and Mad River hatcheries (SSHAG 2003).

23.2.1.2 Similarity between Hatchery-origin and Natural-origin Fish

Through microsatellite DNA analysis, it has been determined that IGH coho salmon group closely with the TRH and Trinity River stocks within the northern group of SONCC genetic structure, distinct from the southern coho samples (SSHAG 2003). It is believed that the IGH coho salmon may be somewhat diverged from the local natural populations and influenced by previously introduced non-local stock (SSHAG 2003). Historical coho salmon run timing is October to December, peaking in November. Current escapement to IGH peaks in November to mid-December, because of the hatchery location at the upper range of coho salmon distribution (K. Rushton, CDFG, personal communication). The natural coho salmon life history consists of a three-year cycle. Adults spawn in tributary streams and juveniles rear in the streams and rivers for the first 15 to 20 months before migrating out to the ocean. Precocial coho salmon return at two years of age. Parr smolts begin migrating downstream in the Klamath basin between February and mid-June. Hatchery coho salmon spend the first 15 months in the hatchery facility before their release as smolts to facilitate their movement directly to the sea. This has been confirmed at the screw trap in the Orleans estuary, where 60 to 70% of the trapped smolts are of hatchery origin. It is unknown if the incidence of 2-year old grilse returns to IGH is reflected in the natural population. Limited information exists for Klamath River coho salmon adult returns, because it is difficult to maintain census operations under high flow conditions (CDFG and NOAA Fisheries 2001).

23.2.1.3 Program Design

The goals for the IGH coho salmon program include the production of 75,000 yearling coho salmon, which are released at 10-20/lb between March 15 and May 1. Current production goals do not include coho salmon conservation. Only Klamath River fish entering the hatchery volitionally may be used as program broodstock. IGH production goals are based on estimated loss of historical production above Iron Gate Dam. Broodstock is collected randomly throughout natural run timing and includes the incorporation of natural coho in the ratio of their occurrence in hatchery returns (10 to 50%). Releases of IGH coho salmon have decreased from approximately 147,000 fish (1987-1991) to 72,000 fish (1997-2002). Adult returns have ranged between 4,097 (92% natural) to 169 fish (91% hatchery), averaging 1,737 coho salmon returns between 1996 and 2003. Natural fish are integrated into IGH broodstock in the ratio of their incidence in fish numbers entering the hatchery, 6% to 100% over the last eight spawning seasons (K. Rushton, CDFG, personal communication). Coho salmon that enter the hatchery in excess of broodstock needs are culled, following CDFG policy. As of 1997, all IGH-produced coho salmon juveniles are externally marked by a left-maxillary clip.

23.2.1.4 Program Performance

The IGH coho salmon program will continue to be funded by PacifiCorps for the duration of its continued operation. There are no reliable time series of natural adult migrants or spawners for SONCC ESU rivers (BRT 2003), and there is no monitoring component to evaluate the mitigation program and its effects on the natural population. Spawning and carcass surveys specific to coho salmon are not conducted in the Klamath River basin, as seasonal high flow conditions prohibit sampling for most of the adult coho salmon run. Information on juvenile outmigration is collected at the Big Bar trapping site in the Klamath River (USFWS 2001). An abundance index is extrapolated from coho salmon numbers trapped each season. Age-0 coho salmon made up 73%, natural age-1+ fish made up 17%, and hatchery fish age-1+ made up 11% (range 6% to 17%) of the total fish outmigrating in the 1997 through 2000 seasons. The low incidence of age-1+ coho salmon in the Big Bar trap reflects the late start-up of operations into the yearling migration and the success of the larger fish in evading the trap. The estimated abundance index for all four seasons totaled 16,106 fish, derived from 152 trapped coho salmon. Age-0 coho salmon were captured from late February to early July, and age-1+ coho salmon (natural and hatchery) were captured in early May to mid-June. IGH releases coho salmon yearlings in late March. Release-to-return survival rates and cohort replacement rates have not been calculated for the IGH coho salmon program.

Continued operation of the IGH coho salmon program is uncertain. There is a strong indication that the program, as currently operated, may be hindering the recovery of the natural coho salmon population. Consideration is being given to its continuation, reduction, or conversion to a conservation program through the FERC relicensing process for KHP.

23.2.1.5 VSP Effects

Based on incidental field information and the composition of adult escapement to the hatchery, the majority of returns are of hatchery origin. There has been an increase in numbers of unclipped coho salmon entering the hatchery 2001-2003, which may be partly due to increasing contribution of hatchery fish to the spawning population or to beneficial ocean conditions, or a combination of those and several other factors. Until there is a monitoring program for coho salmon in the Klamath River, it will be difficult to corroborate hatchery contribution to population productivity. There is the possibility that the IGH program is having an adverse effect on the survival of wild juveniles through competitive and aggressive interactions with hatchery fish. It is not known if population spatial structure has benefited from hatchery fish, although it appears that SONCC populations have stabilized overall at a low level since the late 1980s (NRC 2003).

23.2.2 Trinity River Hatchery

Natural coho populations have experienced an approximate reduction of 96% in the Trinity River, declining to a few hundred individuals (NRC 2003; CDFG 2002a). The natural coho salmon populations are affected by the Trinity River Hatchery (TRH) artificial propagation program which releases its annual coho salmon production within the Trinity River basin. The TRH program is considered part of the SONCC ESU.

23.2.2.1 Program History

Artificial propagation at TRH began in 1960 as mitigation for the loss of 109 miles of habitat above Lewiston dam. The goals of the TRH program do not include coho salmon conservation. The TRH stock was originally founded with local native fish stock from the Eel, Cascade, Alsea, and Noyo rivers but has exclusively used returns to the hatchery since 1970 (Israel and Williamson 2003). Local, native fish are integrated into TRH broodstock in the same proportion as the ratio of hatchery and natural fish entering the facility (<10%).

23.2.2.2 Similarity between Hatchery-origin and Natural-origin Fish

Through microsatellite DNA analysis, it has been determined that the TRH stock clusters with the IGH and Trinity River stocks within the Northern group of SONCC genetic structure, distinct from the Southern coho samples. However, TRH coho salmon are also genetically distinct from Deadwood Creek, Trinity River, and IGH stocks. Run timing and spawn timing are the same for both hatchery and natural fish. Coho salmon life history consists of a three-year cycle. Adults spawn in tributary streams, and juveniles rear in the streams and rivers for the first 15 to 20 months before migrating out to the ocean. Precocial coho salmon return at two years of age. Hatchery coho salmon spend the first 15 months in the hatchery facility before their release as smolts, on the assumption that they will head directly to the sea. Both TRH and natural coho salmon were recovered in a 2001 spawning survey, exhibiting the same run timing and spawning period.

23.2.2.3 Program Design

The TRH coho salmon program volitionally releases an average of 525,000 fish annually between March 15 and May (NRC 2003). The carrying capacity of the Trinity River basin is not known, but historical returns have been estimated at 8,000 coho salmon (BRT 2003). Numbers were reduced to 1,700 and 3,100 in 1990 and 1991, respectively. Current production goals do not include coho salmon conservation. Only Trinity River fish entering the hatchery volitionally may be used as program broodstock. Broodstock is collected randomly throughout natural run timing and may include the incorporation of natural coho salmon, in the ratio of their occurrence in hatchery returns (<1-10%). However, due to overwhelming numbers of hatchery fish and low natural productivity in the Trinity River basin, the number of natural fish that may enter the hatchery is very low. Coho salmon in excess of broodstock needs are culled, based on CDFG policy. TRH production goals are based on the estimated loss of historical adult returns above Lewiston Dam. As of 1994, all TRH-produced coho salmon juveniles are externally marked by a right-maxillary clip. Hatchery management and the Hoopa Indian Tribe are exploring the feasibility of 100% thermal marking of all TRH fish to supplement external marking and improve the accuracy and precision of in-river run size and migratory timing estimates for hatchery and natural fish in juvenile outmigrations and adult returns.

Continued operation of the TRH coho salmon program will continue. There is a strong concern that the large numbers of coho salmon hatchery releases need to be evaluated in terms of the recovery and/or restoration of natural Trinity River coho salmon populations.

23.2.2.4 Program Performance

The percentage of coho salmon returns entering TRH has ranged from a low of 22% in 1998 to high of 34% in 1994, averaging 32% since 1986 (Kruzic and Bryant 1998). Fish returns number between 23,338 (1987) to 294 fish (1995), averaging 6,115 coho salmon returns between 1986 and 1998. TRH coho salmon stray within the basin (BRT 2003; CDFG and NOAA Fisheries 2001) and were recorded in the 2001 Trinity River mainstem carcass survey (NRC 2003; Sinnen 2002). Most of the 692 coho salmon carcasses were found in the uppermost reach near Lewiston Dam (Sinnen 2002). An estimated 75.9% of the spawners were of hatchery origin. Results of juvenile coho salmon trapping in the lower Trinity River indicate that 65 to 97% of the 1998-2000 catch were hatchery fish, and an estimated 85 to 95% of the 1997-2001 in-river spawners upstream of the South Fork Trinity River were stray fish from TRH. There is a dichotomy in size between hatchery and natural migration. Hatchery fish reach the estuary at the same time as wild smolts, in late May and early June, arriving at 170-185 mm in length compared to 135–145 mm of wild fish (NRC 2003).

Information on juvenile outmigration is collected at the Willow Creek trapping site in the Trinity River (USFWS 2001). An abundance index is extrapolated from the numbers of coho salmon trapped each season. Age-0 coho salmon made up 7%, natural age-1+ fish made up 7%, and hatchery fish age-1+ made up 86% (range 62 to 92%) of the total fish outmigrating in the 1997-2000 seasons. Coho salmon age-0 were captured from late February to early July. Coho salmon age-1+ (natural and hatchery) were captured in early May to mid-June. TRH releases coho salmon during late March. The low incidence of age-1+ coho salmon in the Willow Creek trap reflects the success of the larger fish at evading the trap. The estimated abundance index for all four seasons totaled 182,294, derived from 2,813 trapped coho salmon.

23.2.2.5 VSP Effects

The majority of juvenile coho salmon out-migrating from the Trinity River basin are hatchery stock; 85-95% of the few naturally-spawning fish are hatchery adult returns (CDFG 2002a). There may be outbreeding effects due to the large numbers of hatchery fish in the system (SWFSC 2001), with little infusion of wild genes in the hatchery population, resulting in selection for domestication (Israel and Williamson 2003). A high straying rate by hatchery coho salmon likely results in introgression with natural fish in the Trinity River basin, impacting the natural genome. There may be outbreeding effects due to large numbers of hatchery fish in the system (SWFSC 2001). An initial 2001 coho salmon carcass survey did not cover Trinity River tributaries, which are the preferred spawning habitat for coho salmon. It is likely that TRH fish are the primary contributors to the current spatial structure. TRH has been recognized as having the potential to be used in restoration work, since there is no known natural population in the Trinity River system (CDGF and NOAA Fisheries 2001).

23.2.3 Rogue River

The TRT for the SONCC coho salmon ESU has not published its population designations at this time. The Rogue River may have more than one population of coho salmon. For the purposes of this assessment, the entire run in the Rogue River was considered.

23.2.3.1 Program History

The current broodstock was founded in 1974 from returns to Cole Rivers hatchery at the base of Lost Creek Dam, the uppermost extent of salmon migration in the Rogue River. Since the late 1990s, significant numbers of natural coho salmon have been incorporated into the broodstock. In some years, the broodstock was composed entirely of natural fish. The management goal is to incorporate at least 30% natural fish into the broodstock annually.

23.2.3.2 Similarity between Hatchery-origin and Natural-origin Fish

The hatchery stock is being managed as a “wild type” broodstock. The intent is to collect broodstock in a manner that represents the run timing, spawn timing, and length distribution of the natural coho run in the Upper Rogue River (ODFW 1998). Genetic samples of the hatchery stock clustered with other natural coho stocks included in the SONCC ESU (Weitkamp *et al.* 1995). Returning hatchery and natural coho salmon above Gold Ray Dam exhibit similar run timing, adult age distribution, and length.

23.2.3.3 Program Design

This program is intended to mitigate for fishery losses from the construction of Lost Creek Dam on the Rogue River. All of the hatchery fish are adipose fin-clipped for recreational fisheries in the ocean and Rogue River. Program fish are not used to supplement natural spawning. The goal is for less than 10% of natural spawners to be hatchery-origin (ODFW 1998).

23.2.3.4 Program Performance

The smolt-to-adult survival rate of the Cole Rivers Hatchery stock has averaged 3% for brood years 1987-1996 (ODFW 1998). The broodstock goal for the current production level is approximately 300 fish. Total returns of coho salmon to the hatchery trap have exceeded the broodstock goal every year since the program was initiated. The program is funded by the Corps and ODFW. The long-term funding outlook for this program is very certain.

23.2.3.5 VSP Effects

Abundance – Long-term run estimates of coho salmon are available from Gold Ray Dam. From 1942 to 2003, an average of 2,200 natural fish passed the dam. In the last two decades the run of coho salmon has steadily increased (Figure 23.1), with the highest runs on record occurring in 2000 through 2002. The average number of hatchery coho salmon crossing Gold Ray Dam from 1980 to 2003 has been 6,200 fish.

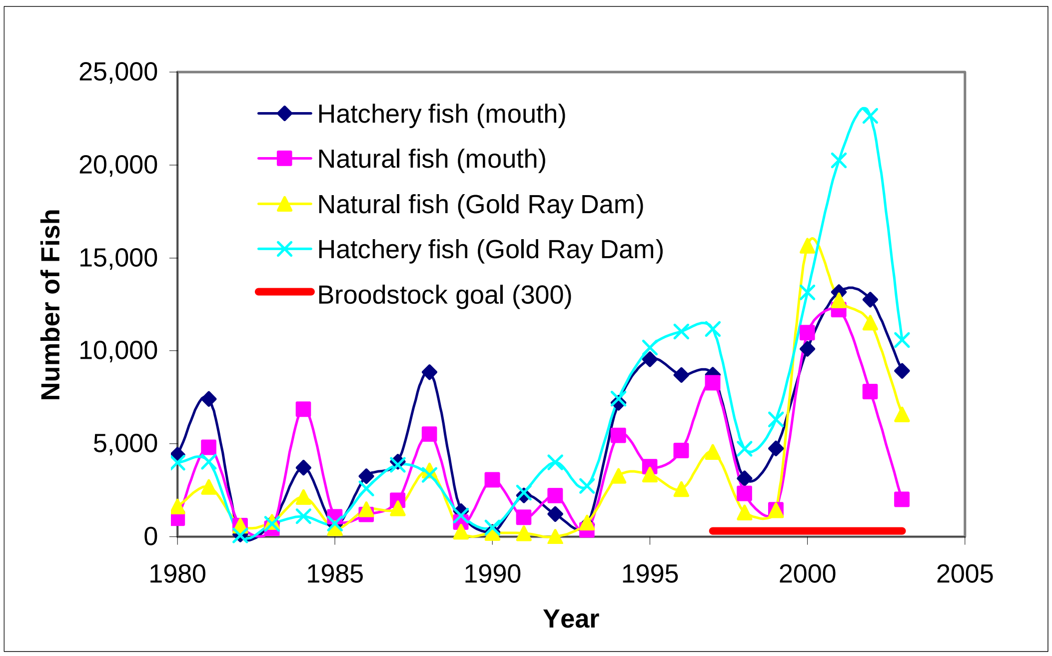

Figure 23.1. Estimated return of coho salmon to the mouth of the Rogue River and Gold Ray Dam (located upstream approximately 150 miles), and the current broodstock goal.

Spawning surveys have shown hatchery fish to represent less than 10% of the spawners throughout the Rogue basin in recent years (ODFW 1998). The releases of hatchery fish in the Rogue River have been reduced over the last decade.

Sufficient numbers of natural and hatchery coho salmon return to the hatchery every year to meet broodstock needs. In the last few years, the natural run of coho salmon has been high, and the hatchery has used solely natural fish for broodstock. The broodstock is being managed as a wild-type broodstock. The program is providing a genetic reserve of the coho run above Gold Ray Dam that may be used in the future for recovery purposes if the natural run becomes depressed.

Productivity - Given the relatively low number of fish released in the Rogue River and the low percentage of natural spawners that are hatchery fish, it is not likely the program is benefiting the productivity of the natural run.

Spatial Structure - The hatchery is located at the base of Lost Creek Dam, an impassable dam with no anadromous fish production above the reservoir. Hatchery fish are not being outplanted to any areas in the Rogue Basin. There is little to no effect of the hatchery program on the spatial structure of the natural run.

Diversity - The hatchery program incorporates natural coho into the broodstock on a regular basis. The intent is to collect broodstock that mimics the run timing, spawn timing, and body length of natural fish returning to the local area.

23.3 CONCLUSION

Existing Status: Threatened
BRT Finding: Threatened
Recommendation: Threatened

23.3.1 ESU Overview

23.3.1.1 History of Populations

The Technical Recovery Team for this ESU has not published its list of historical populations. Current abundance of natural coho salmon in the ESU is substantially below historical levels in California rivers (BRT 2003). The run of coho salmon in the Rogue River has exhibited a positive trend over the last 20 years. Little information is available from other rivers in Oregon. Coho salmon populations in the Klamath Basin have declined precipitously over the last 60 years, and coho salmon presence in the Klamath and Trinity Rivers is primarily from hatchery production.

23.3.1.2 Association between Natural Populations and Artificial Propagation

Natural populations "with minimal genetic contribution from hatchery fish" – There are three hatchery programs in the ESU located in the Trinity, Klamath, and Rogue Rivers. These rivers represent a substantial area of the ESU. In the Rogue River, the percentage of hatchery coho salmon on the spawning grounds throughout the basin has been low in recent years. Most of the natural spawning of coho salmon in the Rogue Basin has had minimal spawning from hatchery coho salmon with the exception of the area near Cole Rivers Hatchery. The highest percentage of hatchery fish among natural spawners has been observed here. However, hatchery fish made up less than 10% of the natural spawners above Gold Ray Dam in recent years. In the rivers within the ESU other than the Trinity and Klamath rivers, the number of hatchery fish spawning naturally would be expected to be minimal.

Return of coho salmon to the Trinity and Klamath rivers is predominately hatchery coho salmon. Therefore, it is expected natural spawners would be mostly hatchery fish and heavily influence coho salmon populations in their basins. The Shasta, Scott, and Salmon rivers do not have a hatchery presence. Coho salmon production from these basins are primarily of natural stock but may be influenced by hatchery fish strays.

Natural[1] populations "that are stable or increasing, are spawning in the wild, and have adequate spawning and rearing habitat"[2] – In the few areas within the ESU where coho salmon returns can be monitored, information suggests returns have increased over the last few years. However, the long-term trends over the last 100 years are negative for all of the natural populations. The current abundance in California rivers is estimated to be less than 10% of historical abundance (BRT 2003).

Mixed (Integrated Programs[3]) – Trinity, Iron Gate, and Cole Rivers hatchery stocks.

Hatchery (Isolated[4]) – None.

23.3.2 Summary of ESU Viability

23.3.2.1 Abundance

The highest risk factors for this ESU were abundance and productivity (BRT 2003). The number of natural-origin coho salmon spawners increased in the Rogue River since 1997. The long-term trend over the last 20 years for the return of coho salmon in the Rogue River is positive. The current abundance of coho salmon in California rivers is estimated to be less than 10% of historical levels and exhibits a long-term negative trend (BRT 2003). Most of the natural spawners are of hatchery origin in the Trinity and Klamath basins.

---

[1] See HLP for definition of natural, mixed and hatchery populations

[2] HLP Point 3

[3] Integrated programs follow practices designed to promote and protect genetic diversity and only use fish from the same local population for broodstock (both natural-origin fish, whenever possible, and hatchery-origin fish derived from the same local population and included in the ESU). Programs operated to protect genetic diversity in the absence of natural-origin fish (e.g., captive broodstock programs and the reintroduction of fish into vacant habitat) are considered "integrated."

[4] Isolated programs do not follow practices designed to promote or protect genetic diversity. Fish that are reproductively isolated are more likely to diverge genetically from natural populations included in the ESU and to be excluded themselves from the ESU.

23.3.2.2 Productivity

The highest risk factors for this ESU were abundance and productivity (BRT 2003). The long-term productivity rate trend for the ESU is negative. The BRT (2003) expressed concern whether coho salmon populations would be able to sustain themselves under current habitat conditions during the next cycle of poor ocean conditions.

23.3.2.3 Spatial Structure

Much of the historical spawning habitat is still accessible to coho salmon. However, current habitat conditions are degraded, and the overall carrying capacity of the streams is reduced (BRT 2003). Several Federal dams in the ESU have also blocked access to upstream spawning areas. Hatchery fish are not being outplanted into unoccupied habitat. Operation of the hatchery facilities represents a negligible effect on the overall distribution and migration of juvenile and adult coho salmon in the ESU.

23.3.2.4 Diversity

All three of the hatchery stocks are integrated with local, natural fish. However, since significant numbers of natural fish have not been incorporated into the Trinity and Iron Gate hatchery broodstocks, there are potential risks from the high numbers of hatchery fish introgressing with natural fish in the wild. It is not fully known what effect the hatchery programs may be having on the diversity of the ESU as a whole.

23.3.3 Artificial Propagation Record

23.3.3.1 Experience with Integrated Programs

The Trinity, Iron Gate, and Cole Rivers hatchery stocks are integrated with natural-origin coho salmon. All of these programs have been in operation for more than a decade.

23.3.3.2 Data on Whether Integrated Programs Are Self-sustaining

The Trinity, Iron Gate, and Cole Rivers hatchery programs have exceeded broodstock goals nearly every year since the programs were initiated. Spawner-to-spawner replacement rates have averaged more than one since the programs have been in operation. See Results Section for further information.

23.3.3.3 Certainty that Integrated Programs Will Continue to Operate

All of the integrated programs are funded by state and Federal agencies. Continued funding of the Trinity and Cole Rivers hatchery programs are certain, since the programs mitigate for the effects of dams. Continued operation of the Iron Gate coho salmon program is being evaluated within the FERC relicensing of the Iron Gate Project and may be modified for conservation purposes, reduced in scope, or discontinued.

23.3.4 Summary of Overall Extinction Risk Faced by the ESU

The Southern Oregon Northern California coho salmon ESU faces the highest risks in terms of low abundance and low productivity. All abundance estimates available for the ESU show current runs to be less than 10% of historical abundance in most of the rivers in California. The strongest run of coho salmon has been in the Rogue River, and it has shown an increasing trend over the last two decades. The current hatchery programs are providing some benefit to the abundance of coho salmon in the Trinity, Klamath, and Rogue rivers. However, significant numbers of naturally spawning hatchery fish in the Trinity and Klamath basins and subsequent effects on the productivity and diversity of natural populations are of major concern.

23.4 LITERATURE CITED

Brown, L. R., P. B. Moyle and R. M. Yoshiyama. Historical decline and current status of coho salmon in California. North American Journal of Fisheries Management: vol.14(2): 237-261.

BRT (West Coast Salmon Biological Review Team). 2003. Updated status of Federally listed ESUs of West Coast salmon and steelhead. Northwest Fisheries Science Center, Seattle, Washington; Southwest Fisheries Science Center, Santa Cruz Laboratory, Santa Cruz, California. July 2003.

California Department of Fish and Game (CDFG). 1965. California fish and wildlife plan. Sacramento, CA. (Available from California Department of Fish and Game, Inland Fisheries Division, 1416 Ninth St., Sacramento, CA 95814.)

CDFG (California Department of Fish and Game). 1994. Petition to the California Board of Forestry to list coho salmon (*Oncorhynchus kisutch*) as a sensitive species. Calif. Dep. Fish Game Rep., 35 pp. plus appendices.

__. 2002a. Status review of California coho salmon north of San Francisco. Report to the California Fish and Game Commission Candidate species status review report 2002-3. 232pp.

__. 2002b. Shasta River Fish Counting Facility, chinook and coho salmon observations in 2002, Siskiyou County, CA. Final Report 8/22/2003. 17pp.

CDFG and NOAA Fisheries (National Marine Fisheries Service). 2001. Final report on anadromous salmonid fish hatcheries in California. Joint Hatchery Review Committee. December 2001.

Elder, D., B. Olson, A. Olson, J.Villeponteaux, and P. Bucker. 2002. Salmon River Subbasin Restoration Strategy: Steps to recovery and conservation of aquatic resources. Prepared for the Klamath River Basin Fisheries Restoration Task Force, Yreka Fish and Wildlife Office, Yreka, CA. 53 pp.

Israel, J. A. and K. S. Williamson. 2003. Investigation of anadromous fish genetics in the Klamath hydroelectric project area. Draft. Klamath Hydroelectric Project FERC Project 2082, contract no. 3000021859.

Kruzic, L. and G. Bryant. 1998. Estimated take of coho salmon in the SONCC ESU associated with inland fisheries and hatcheries. Memorandum for F/PR3 - Craig Johnson. 9pp.

NOAA Fisheries (National Marine Fisheries Service). 1997 Final Rule: Endangered and Threatened Species; Threatened Status for Southern Oregon/Northern California Coast Evolutionarily Significant Unit (ESU) of Coho Salmon. May 6, 1997; 62 FR 24588.

__. 2002. Klamath Project Operations. Biological opinion. May 31, 2002. National Marine Fisheries Service Arcata Field Office.

NRC (National Research Council). 2003. Endangered and threatened fishes in the Klamath River Basin: causes of decline and strategies for recovery. Committee on Endangered and Threatened fishes in the Klamath River Basin. The National Academies Press, Washington, D.C.

ODFW (Oregon Department of Fish and Wildlife). 1998. Cole Rivers Coho Salmon Hatchery and Genetics Management Plan. Fish Division. Portland, Oregon.

SHAGG (Salmon and Steelhead Hatchery Assessment Group). 2003. Hatchery broodstock summaries and assessments for chum, coho, and Chinook salmon and steelhead stocks within evolutionarily significant units listed under the Endangered Species Act. Northwest Fisheries Science Center, Seattle, WA, and the Southwest Fisheries Science Center, La Jolla, CA. May 2003.

Sinnen, W. 2002. Trinity River Basin salmon and steelhead monitoring project 2001-02 season. Task 4: salmon spawner surveys in the upper Trinity River. Annual Report. CDFG in cooperation with the Yurok Tribe and USFWS.

SWFSC (Southwest Fisheries Science Center). 2001. Status review update for coho salmon (Oncorhynchus kisutch) from the Central California Coast and the California portion of the Southern Oregon/Northern California Coasts evolutionarily significant units. SWFSC-Santa Cruz Laboratory.

USFWS (U.S. Fish and Wildlife Service). 2001. Juvenile salmonid monitoring on the mainstem Klamath River at Big Bar and mainstem Trinity river at Willow Creek, 1997-2000. Annual report of the Klamath River Fisheries Assessment Program. Arcata Fish and Wildlife Office, Arcata, CA.

Weitkamp, L. A., T. C. Wainwright, G. J. Bryant, G. B. Milner, D. J. Teel, R. G. Kope and R. S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-24.

NOAA FISHERIES
SALMON RECOVERY DIVISION
PROPAGATION AND TRIBUTARY FISHERIES BRANCH
Lacey, Washington

TO:	Rob Jones
FROM:	Tim Tynan
DATE:	March 3, 2005
SUBJECT:	Suggested SSHAG document changes for Puget Sound chinook salmon hatchery populations.

Following are some suggestions for revising the Salmon and Steelhead Hatchery Assignment Group (SSHAG) document that was released in final draft form in June, 2003 (NWFSC 2003). In addition to my own thoughts regarding needed changes, these suggestions consider recommendations submitted by the co-managers and the public in their review comments on the proposed Hatchery Listing Policy, the SSHAG category assignments, and our resultant ESA listing proposals. Included are recommendations for reconciling differences between: NWFSC proposals for hatchery population categorization in the Puget Sound chinook salmon ESU; SRD findings carried forth in the Salmon Hatchery Inventory and Evaluation Report (SHIER) last April; and proposals recently provided by the co-managers (Spidle and Currens 2005; J. Koenings, 2004). Some of the following suggestions for modification also apply to the draft Hatchery Listing Policy, where certain SSHAG-derived terms and definitions were used.

General comments:
Determinations regarding hatchery population ESU status could be improved if key terms included in the SSHAG document, and then in the draft Hatchery Listing Policy, were clearly defined. An explanation of how the terms were then applied in evaluations of genetic and other forms of divergence used to make hatchery population category assignments is also needed. The terms were introduced in the SSHAG definition of "moderate divergence"; a definition subsequently applied in the draft Hatchery Listing Policy to identify criterion to be used in making ESU and listing determinations for hatchery populations. The Hatchery Listing Policy restated the SSHAG "moderate divergence" definition in the second bullet of the five point policy:
"Hatchery fish with a level of **genetic divergence** between the hatchery stocks and **the local natural populations** that is no more than what would be expected between **closely related populations** within the ESU …. "

In their October 20, 2004 review comments on the Hatchery Listing Policy, the Center finds that the above cited section of the policy is "clearly stated and unambiguous". However, it is clear from a review of public review comments that the definition did not lead to a transparent understanding of how hatchery population ESU determinations were made in the SSHAG and SHIER documents. To understand how the SSHAG and NWR applied the subject definition and policy statement, definitions of each of the above bolded terms, and the approach used to make hatchery populations category assignments using the terms, are needed.

“Genetic divergence” - Although the draft Hatchery Listing Policy defines “level of genetic divergence” as the sole means for divining the ESU status of hatchery populations, other measures not defined in the five points policy were also used to make SSHAG and SHIER categorization calls. In instances where genetic data for a hatchery population are entirely absent, the “level of genetic divergence” criterion was not used by the SSHAG and SHIER at all in assigning categories.

In the SSHAG document, hatchery stocks were assigned to a category based on an assessment of variation across three axes: 1) the degree of genetic divergence between the hatchery stock and the natural population(s) that occupy the watershed into which the hatchery stock is released; 2) the origin of the hatchery stock; and 3) the status of the natural population(s) in the watershed. The first axis is the lone criterion included in the Hatchery Listing Policy. The second two are not defined for use in assessing hatchery population similarities or differences in the policy. The additional use of hatchery stock origin and natural population status to make hatchery categorization calls by SSHAG, and by the NWR in the SHIER documents, has led to a misunderstanding of the approach NMFS applied in proposing in or out of ESU determinations (see co-manager and RSRP comments on the Hatchery Listing Policy and proposed hatchery population categorizations).

To clarify our approach, we could revise “point 2” of the Hatchery Listing Policy to specifically include *hatchery stock origin* and *natural population status* as additional criteria that are used to determine the ESU status of hatchery populations. As an alternative, the SHAGG document could be augmented to indicate why, and under what circumstances in particular, it is appropriate to consider these criteria in addition to “the degree of genetic divergence”. Clarity regarding weight given to these latter two criteria in making category designations is also needed. Note that in the SSHAG definition of “minimal divergence” (the first introduction of the term “divergence”), the term is qualified to mean “no appreciable *genetic* divergence”. The degree of *genetic* rather than other potential forms of divergence is thus implied as the main standard used for subsequent SSHAG definitions of “moderate”, “substantial” and “extreme” divergence. Again, genetic data are lacking for certain hatchery populations, and we should clarify that categorization proposals are also based on other considerations besides degree of genetic divergence.

“Local natural population” - In each SSHAG document section evaluating an individual hatchery population, the specific “local natural population” that was used as the reference or benchmark population for gauging the degree of hatchery population genetic (and other) divergence should be clearly identified. As written, identification of the specific “natural population(s) that occupy the watershed into which the hatchery stock is released” (as defined in the first “axis” of the SSHAG document) is unclear. The rationale for choosing the identified natural population as the “benchmark” for divergence evaluations should also be provided.

For example, in the evaluation of the Issaquah Hatchery fall chinook population, it would be helpful to clearly identify (acknowledging the stock transfer and straying history of the hatchery population, and Puget Sound TRT population identification proposals for Puget Sound) whether the “local natural population” serving as the benchmark for the NWFSC evaluation is the historically extant Sammamish River population, the currently extant Sammamish River population, the apparent natural-origin spawning aggregation in Issaquah Creek, or the original donor Green River population for the program. To highlight this need, in assessing this program, the NWFSC apparently assumed that the currently extant natural spawning aggregation in Issaquah Creek was the reference stock (by all indications, progeny of naturally spawning Issaquah Hatchery fish), the NWR assumed the Green River population as the benchmark for review (as the donor lineage used to establish a chinook return to Issaquah Hatchery and Issaquah Creek), and WDFW and the NWIFC (Koenings, 2005; Spidle and Currens 2005) assumed that the extant Sammamish River population was the appropriate reference local natural population (linking the TRT's identification of Issaquah Creek as part of that delineated chinook population including Bear and Cottage creeks). Using another stock circumstance, is the benchmark for the Grovers Creek Hatchery fall chinook population the Green River population (the original donor lineage for the program) or some other population, given that there is no "local natural chinook salmon population" occupying any of the East Kitsap region watersheds? Considering an intermediate (co-manager "category 2") stock circumstance, is the benchmark, local population for the Clear Creek/Kalama Creek hatchery fall chinook population the historically extant Nisqually River natural population, the currently extant Nisqually River natural population, or the Green River population (a hatchery derivative of the latter that has likely supplanted any indigenous Nisqually chinook population)?

Applying the Hatchery Listing Policy term ("the local natural populations"), the SSHAG document application of the term ("the natural population(s) that occupy the watershed into which the hatchery stock is released"), and Puget Sound TRT chinook population delineations (which identifies currently extant populations), the reference local natural population used in our evaluation should be the currently extant TRT-delineated natural-origin chinook salmon population in the watershed where the hatchery program releases its fish.

"Closely related populations" - The SSHAG evaluation, and the Hatchery Listing Policy-derived categorization proposals, would be more transparent if a standard for gauging "expected" genetic (and other?) divergence between what the NWFSC considered to be "closely related populations" was provided. This standard would be assumed for subsequent evaluations of the genetic relationship between each individual hatchery population and its identified "local natural population". For those populations for which sufficient genetic data are available, the Center could assume some acceptable measure of genetic distance (taken from allele frequency estimates) that would be used to define a set of closely related chinook populations in Puget Sound. Perhaps a maximum "allowable" difference in Cavalli-Sforza and Edwards' distance measures might be defined to make a "closely related" call regarding the hatchery population and its identified local population. Spidle and Currens (2005) suggest that F_{st} values could be derived from available genetic data, with pair-wise tests for significance indicating whether divergence between populations could be considered significant or not. As an alternative, perhaps the Center could select two populations in the region that would serve as templates for defining "closely related populations", based on genetic, ecological and stock transfer history considerations.

Specific comments:

1. SSHAG category designations for hatchery populations located in Puget Sound watersheds where chinook salmon as a species are non-indigenous.

The SSHAG document categorized seven Green River hatchery-lineage fall chinook salmon populations located and released into watersheds where no local natural chinook salmon populations exist as exhibiting moderate divergence from "the local natural populations that occupy the watershed into which the hatchery stock is released". In each instance, the categorization assignments for these populations (defined as "2s" by the SSHAG) is qualified by the acknowledgment that the hatchery populations were founded non-locally and released into a watershed that lacks a native natural population. These "category 2b" hatchery populations were Issaquah Creek, Grover's Creek, Garrison Springs (Chambers Creek), Minter Creek, Tumwater Falls, Big Beef Creek, and Glenwood Springs.

The categorization of these populations as "2s" is inconsistent with SSHAG's defined approach for making divergence determinations, and with the Hatchery Listing Policy approach for determining hatchery population ESU status. There are no historically or currently extant local natural populations occupying the watershed into which the hatchery stocks are released (as per Ruckelshaus et al., in press) that can serve as benchmarks for assessing divergence. As a consequence, any categorization of the degree of divergence for these hatchery populations is inconsistent with the root basis for assignment defined by SSHAG, and with the criterion carried forth in the Hatchery Listing Policy. The lack of a reference historically or currently extant local natural chinook salmon population in the watersheds is sufficient rationale, given direction provided in SSHAG document and in the Hatchery Listing Policy, to exclude the hatchery populations from the ESU.

Stock transfer history (they are all transplanted hatchery-origin stocks that are managed to be localized to the "non-chinook" watershed release point, and self-sustaining in broodstock returns) and the management strategy and intent for these programs (few or no natural-origin fish are incorporated as broodstock, few or no natural fish result from natural spawning by program fish, and no measures to maintain genetic or ecological characteristics of the original donor hatchery chinook population were ever applied) should also be highlighted as primary supportive rationale for excluding the populations from the ESU. The populations have been managed to be ecologically and genetically disconnected from the original donor Green River hatchery population, and from other natural chinook populations. With the possible exception of the Issaquah Hatchery population (see comments below), they also lack an associated local natural population because they are released into watersheds with no historical or currently extant chinook populations. The NWR applied the above rationale in proposing the exclusion of these hatchery populations from the Puget Sound chinook salmon ESU in the SHIER document (NMFS 2004). No substantive comments challenging the basis for these re-categorizations and "out-of-ESU" calls by the NWR were submitted through the public review process for the proposed SHIER, SSHAG, and Hatchery Listing Policy documents, with the exception of the Issaquah Hatchery population. The National Homebuilder's Association did identify categorization differences between SSHAG and SHIER documents for these populations, but noted that the populations were not located in watersheds where chinook salmon were indigenous (Kilmer, 2004). Inclusion within the ESU, and attendant extension (as proposed) of ESA protective provisions into the watersheds where six of the seven subject hatchery populations are released, are inappropriate.

2. Categorization of the Issaquah Hatchery fall chinook salmon population.
As noted above, the SSHAG used the naturally spawning chinook aggregate in Issaquah Creek as the benchmark natural population for its assignment of the Issaquah Hatchery as a category "2b" population. NWR reassigned the hatchery population as category "3" in its SHIER document, noting the lack of a natural population in Issaquah Creek, and determining that the population was substantially diverged from the Green River population (the assumed benchmark "local" natural population) originally used as the donor stock for the hatchery-origin broodstock

transferred to found the program (NMFS 2004). Based on this reassignment, the NWR proposed that the Issaquah Hatchery population be excluded from the ESU.

In public review comments submitted to NMFS, the NWIFC (Spidle and Currens 2005), WDFW (Koenings 2004), and two other commenters (City of Seattle 2004; Urabek 2004) proposed that the Issaquah Hatchery population be re-categorized and re-assigned as a within-ESU population. Highlighting the aforementioned need for clear definition of terms, the NWIFC conducted its evaluation of the Issaquah Hatchery population based on its own interpretations regarding the reference local natural population (assumed by them to be the extant Sammamish River population), and what is meant by "closely related" and "distantly related" populations (their pair-wise comparisons of F_{st} values) (Spidle and Currens 2005). Using the extant Sammamish River chinook population as the reference associated natural population, the NWIFC and WDFW concluded that the lack of genetic divergence between the Issaquah Hatchery and Sammamish natural populations warrants the inclusion of the hatchery population in the ESU, consistent with the NMFS Hatchery Listing Policy definition.

The Puget Sound TRT includes Issaquah Creek as one of the group of North Lake Washington tributaries historically or currently occupied by the Sammamish River chinook population (Ruckelshaus et al., in press). However, information indicating the presence of the species prior to the propagation and release of Green River Hatchery lineage fall chinook into the creek beginning in 1937 through the Issaquah Hatchery program is lacking. Genetic and stock status evaluations of chinook salmon returning to Issaquah Creek indicate that natural-origin fish are largely if not entirely the progeny of naturally spawning hatchery fish (Young and Shaklee 2000; Marshall 2000a; A. Marshall, draft report, October, 2004). Although the Issaquah chinook genetically group closely to other south Puget Sound populations, Young and Shaklee (2000) reported that Issaquah Creek chinook were significantly different from Soos Creek Hatchery chinook, the Green River lineage used to found the Issaquah Hatchery program. The Issaquah Creek natural and hatchery-origin fish have also been shown not to be significantly different from naturally spawning chinook salmon in Cottage and Bear Creeks (Marshall 1999; 2000; Young and Shaklee 2000). Considering hatchery management measures, the Issaquah Creek hatchery program has been operated for the express purpose of producing adult fish for harvest in an isolated setting (WDFW 2003a). It has never been the intention of the program to seed natural habitat in the Sammamish watershed, nor to make hatchery fish produced through the program resemble any natural-origin chinook aggregation in the watershed either genetically or ecologically through purposeful incorporation of natural-origin fish as broodstock (WDFW 2003a). It is highly likely that the Issaquah Hatchery population (of known Green River hatchery origin based on the stock transfer and hatchery management histories) are not genetically divergent from the extant Sammamish River chinook population because the extant Sammamish population was established, and is presently sustained by, stray Issaquah Hatchery fish spawning.

Although acknowledging the non-indigenous Green River hatchery origin of the Issaquah Hatchery fall chinook population, and the likelihood that natural-origin chinook in Issaquah Creek and the other Sammamish tributaries are progeny of adults of this non-indigenous origin stock that have spawned naturally, Issaquah Creek is part of the occupied area for the Sammamish River population identified by the Puget Sound TRT. Following guidance provided in the SSHAG document and in the Hatchery Listing Policy, we therefore assume that the extant local natural population that should appropriately be used as the basis for identifying degree of divergence is the extant Sammamish River population. Available genetic data indicates that the Issaquah Hatchery population is not substantially diverged from this reference local natural population. It is therefore appropriate to assign a “category 2” designation to the Issaquah hatchery population, and include that population, in accordance with the proposed Hatchery Listing Policy, as part of the Puget Sound chinook salmon ESU.

3. Categorization of the Hood Canal Hatchery fall chinook salmon populations.
The SSHAG used the naturally spawning chinook aggregate in Skokomish River as the benchmark natural population for its assignment of the George Adams Hatchery fall chinook population (including Rick’s Pond production) and Hoodsport Hatchery population as either a category “2b” or “3c” population. The populations were proposed as category “3c” populations as a precautionary measure pending determination of whether a native fall-run population persists in the Skokomish River watershed. NWR concurred with a category “3” proposal for these populations in the SHIER document (NMFS 2004). The NWR cited as supportive rationale the lack of a natural population in Purdy Creek (WDF 1957) and Finch Creek, the clear non-indigenous origin of the hatchery stocks (the programs were not founded using indigenous chinook), and consideration that the stocks were substantially diverged from the original donor Green River-lineage population used to found and sustain the hatchery populations (the assumed benchmark local natural population used to evaluate ESU status) in NMFS 2004). Genetic analyses and hatchery fish straying data indicating that the fall chinook populations in the Skokomish River and returning to George Adams Hatchery were extensively mixed and genetically similar were acknowledged in the SSHAG, SHIER, and Puget Sound TRT documents (SSHAG 2003; NMFS 2004; Ruckelshaus et al. in press). Applying guidance included in the proposed Hatchery Listing Policy, and assuming the natural Green River population as the local natural population benchmark for applying that guidance, the NWR concluded that the George Adams Hatchery and Hoodsport Hatchery populations should be excluded from the ESU.

The NWIFC proposed that the Hood Canal region hatchery fall chinook populations (including the George Adams and Hoodsport populations) be re-categorized and re-assigned as within-ESU populations (Spidle and Currens 2005). WDFW proposed that the two George Adams hatchery populations be re-assigned, with no mention of the need to reconsider categorization of the Hoodsport Hatchery population (Koenings 2004). The co-managers assume the appropriate local natural population that should be used as the basis for the divergence evaluation for the George Adams Hatchery populations is the extant Skokomish River chinook population. The NWIFC and WDFW concluded that the lack of genetic divergence between the George Adams Hatchery and Skokomish natural populations warrants the inclusion of the two hatchery populations in the ESU, consistent with the NMFS Hatchery Listing Policy standard. It is unclear whether the NWIFC also assumed that the Skokomish population was the appropriate natural reference population for the Hoodsport Hatchery population, or whether they proposed to also include this hatchery population in the ESU.

The Puget Sound TRT concluded that the indigenous late-run component of chinook spawning aggregations in the Skokomish River basin were extinct, replaced by introduced Green River stock and no longer represent the historic populations (Ruckelshaus et al., in press). In addition, historical information indicates that chinook salmon were not present in Purdy Creek (a lower Skokomish River tributary) prior to initiation of the George Adams Hatchery program in 1963 (WDFW 1957). Genetic evaluations of chinook salmon returning to the Skokomish River watershed indicate that the natural- and hatchery-origin populations are not significantly different (Marshall 2000b). The Hood Canal hatchery populations formed a group differentiated from south Puget Sound populations (including Green River), although at a low level (Marshall 2000b). Mark recovery data indicates that a substantial proportion of the annual naturally spawning population in the Skokomish River are stray hatchery-origin fish (WDFW 2003b; Marshall 2000b). This contribution to natural spawning has been inadvertent, as the George Adams and Rick's Pond hatchery program have been operated for the express purpose of producing adult fish for harvest in an isolated setting (WDFW 2003b). It has never been the intention of the programs to seed natural habitat in the Skokomish watershed, nor to make hatchery fish produced through the programs resemble any natural-origin chinook aggregation in the watershed either genetically or ecologically through (for e.g.) incorporation of natural-origin fish as broodstock (WDFW 2003b). It is highly likely that the George Adams-derived hatchery populations (of known Green River hatchery origin based on stock transfer and hatchery management histories) are not genetically divergent from the extant Skokomish River chinook population because a substantial proportion of the extant annual natural spawning Skokomish population is presently sustained by stray first generation hatchery fish spawning, with extremely degraded habitat conditions in the river limiting natural population productivity.

As a lower Skokomish River tributary, Purdy Creek, where the George Adams Hatchery program releases fish and collects broodstock, is part of the occupied area for the Skokomish River population identified by the Puget Sound TRT. Following the standard provided in the SSHAG document and in the Hatchery Listing Policy, we therefore assume that the extant local natural population that should appropriately be used as the basis for identifying degree of divergence is the currently extant Skokomish River population. Available genetic data indicates that the George Adams Hatchery population is not substantially diverged from this reference local natural population. It is therefore appropriate to assign a "category 2" designation to the George Adams and Rick's Pond hatchery populations, and include those populations, in accordance with the proposed Hatchery Listing Policy, as part of the Puget Sound chinook salmon ESU.

Finch Creek, where the Hoodsport Hatchery program is located, historically and currently lacks an extant local natural chinook salmon population (Ruckelshaus et al., in press). As described above, and consistent with Hatchery Listing Policy guidance, this hatchery population will be excluded from the ESU. There is no benchmark natural population for assessing divergence as no natural population exists in the watershed, and the program sustains itself through returns of localized, transplanted Green River hatchery-linage stock with few or no incorporation of natural-origin fish as broodstock.

4. Categorization of the Hamma Hamma Hatchery chinook salmon population.
The SSHAG used the naturally spawning Mid Hood Canal chinook aggregate (Dosewallips, Duckabush, and Hamma Hamma river populations) as the benchmark natural population for its category assignment of the Hamma Hamma Hatchery fall chinook population as either a category "2b" or "3c" population. The population was proposed as a category "3c" population as a precautionary measure, pending determination of whether a native fall-run population persists in the Mid Hood Canal rivers. NWR concurred with a category "3" proposal for the population in the SHIER document (NMFS 2004). The NWR cited as supportive rationale the clearly non-indigenous origin of the hatchery stock (the program was not founded using indigenous chinook), and, as a non-indigenous stock, the contention that the hatchery population

is substantially diverged from the extant natural Mid Hood Canal population (NMFS 2004). From NMFS (2004), genetic characterization of Mid-Hood Canal chinook has been limited to comparison of adults returning to the Hamma Hamma River in 1999 with other Hood Canal and Puget Sound populations (citing SaSI 2003). These studies, although not conclusive (additional genetic data were collected in 2000 and 2001), suggest that Hamma Hamma fall chinook returns are not genetically distinct from the Skokomish chinook population, or from George Adams and Hoodsport Hatchery populations used as broodstock for the Hamma Hamma Hatchery program (SaSI 2003, citing unpublished data from Anne Marshall, WDFW). Straying of chinook originating from southern Hood Canal and hatchery releases into the Mid Hood Canal rivers were considered potential contributing causes of these genetic similarities. Monitoring and evaluation indicates Hamma Hamma Hatchery-origin fall chinook adults are likely increasing the number of naturally spawning chinook salmon in the Hamma Hamma River (SaSI 2003).

The NWIFC and WDFW proposed that the Hamma Hamma Hatchery fall chinook population be re-categorized and re-assigned as within-ESU populations (Spidle and Currens 2005; Koenings 2004). The co-managers assume the appropriate local natural population that should be used as the basis for the divergence evaluation is the extant Hamma Hamma River chinook population. The NWIFC and WDFW concluded that the lack of genetic divergence between the Hood Canal region hatchery populations, and extant natural populations warrants the inclusion of the hatchery population in the ESU, consistent with the NMFS Hatchery Listing Policy standard.

The Puget Sound TRT concluded that the indigenous chinook spawning aggregations in the Mid Hood Canal rivers were extinct, replaced by introduced Green River stock, and no longer represent the historic populations (Ruckelshaus et al., in press). Genetic evaluations of chinook salmon returning to the Hamma Hamma River indicate that returns are not significantly different from fall chinook returning to George Adams Hatchery, Hoodsport Hatchery (1999 samples), and naturally spawning fish in the Skokomish River (Marshall 2000b). It has been the objective of the program to supplement the natural spawning population, and adult returns to the Hamma Hamma River have increased coincident with the supplementation. The hatchery program now applies measures to make hatchery fish produced through the program resemble the extant natural-origin chinook aggregation in the Hamma Hamma watershed through incorporation of returning adult fish as broodstock (½ of annual broodstock needs; ½ are still transferred from George Adams Hatchery) and use of NATURES rearing strategies (LLTK 2003).

The Hamma Hamma River is part of the occupied area for the Mid Hood Canal chinook population identified by the Puget Sound TRT. Following the standard provided in the SSHAG document and in the Hatchery Listing Policy, we therefore assume that the local natural population that should appropriately be used as the basis for identifying degree of divergence is the currently extant Mid Hood Canal population. Available genetic data indicates that the Hamma Hamma Hatchery population is not substantially diverged from this reference local natural population, and that the Green River-derived hatchery population has likely supplanted any indigenous population. It is therefore appropriate to assign a “category 2” designation to this hatchery population, and include it, in accordance with the proposed Hatchery Listing Policy, as part of the Puget Sound chinook salmon ESU.

Cites:

City of Seattle. 2004. Letter from Martin Baker, Seattle Public Utilities to Chief, NMFS regarding comments on the proposed listing determinations. November 12, 2004. 2 p. [plus enclosures].

Killmer, W. 2004. Letter from National Association of Home Builders to G. Griffin, NMFS Protected Resources Division regarding proposed listing determinations for 27 ESUs of West Coast salmonids. November 12, 2004. Washington, D.C. 286p. [including attachments].

Koenings, J. 2004. Letter from Washington Dept. of Fish and Wildlife to Donna Darm, NMFS Protected Resources Division regarding substantive concerns with the proposed listing determinations, specifically the proposed listing of Lower Columbia coho and the exclusion of seven hatchery programs from the Puget Sound chinook and Lower Columbia coho ESUs. November 9, 2004. 2 p. [plus enclosures].

Long Live the Kings (LLTK). 2003. Hamma Hamma fall chinook supplementation program. Long Live the Kings, Seattle, Washington. 46p.

Marshall, A. 1999. Genetic analysis of Bear Creek/Cottage Lake Creek naturally spawning fall-run chinook. Fish Program, Genetic Unit. Washington Department of Fish and Wildlife. Olympia, WA. 6p.

Marshall, A. 2000a. Genetic analysis of Cottage Lake Creek/Bear Creek and Issaquah Creek naturally spawning fall-run chinook. Fish Program, Science Division. Washington Department of Fish and Wildlife. Olympia, WA. 7p.

Marshall, A. 2000b. Genetic analysis of 1999 Hood Canal area chinook samples. May 31, 2000 memorandum. Fish Program, Science Division. Washington Department of Fish and Wildlife. Olympia, WA. 10p.

Marshall, A. 2004. (Draft report). Cedar River chinook escapements and recovery issues: assessment using available data. Fish Program, Science Division. Washington Department of Fish and Wildlife. Olympia, WA. 4p.

Marshall, A., C. Smith, R. Brix, W. Dammers, J. Hymer, and L. Lavoy. 1995. Genetic diversity units and major ancestral lineages for chinook salmon in Washington. IN C. Busack and J. Shaklee (eds.), Genetic diversity units and major ancestral lineages of salmonid fishes in Washington, p. 111-173. Technical Report #RAD 95-02. Washington Department of Fish and Wildlife. Olympia, WA.

National Marine Fisheries Service. 2004. Salmon hatchery inventory and evaluation report – Puget Sound chinook salmon ESU. Salmon Recovery Division. NOAA Fisheries Service. Portland, Oregon. 107p.

Northwest Fisheries Science Center (NWFSC). 2003. Salmon and steelhead hatchery assignment group (SSHAG). 2003. Hatchery broodstock summaries and assessments - chum salmon, coho salmon, chinook salmon, and steelhead within listed salmon and steelhead ESUs. June 16, 2003 draft. Northwest Fisheries Science Center. National Marine Fisheries Service. Seattle, Washington. 296 p.

Ruckelshaus, M., K. Currens, W. Graeber, R. Fuerstenberg, K. Rawson, N. Sands, J. Scott. 2005. Independent populations of chinook salmon in Puget Sound. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-XX, XXX p.

Spidle, A. and K. Currens. 2005. Evidence for including or excluding hatchery stocks from the Puget Sound chinook salmon ESU. Northwest Indian Fisheries Commission. Lacey, WA. 6p.

Urabek, F. 2004. Letter from Frank Urabek to NMFS regarding inclusion of the Issaquah Creek hatchery stock in the Puget Sound chinook ESU. November 5, 2004. 1 p.

Washington Department of Fisheries. 1957. Research relating to fisheries problems that will arise in conjunction with current and projected hydroelectric developments in the Skokomish River. Washington Department of Fish and Wildlife. Olympia, Washington. 64p. [plus appendices].

Washington Department of Fish and Wildlife (WDFW). 2003a. Hatchery and genetic management plan - Issaquah fall chinook program. August, 2002 draft. Fish Program, Science Division. Washington Department of Fish and Wildlife. Olympia, Washington. 27p.

Washington Department of Fish and Wildlife (WDFW). 2003b. Hatchery and genetic management plan - George Adams fall chinook fingerling program. August, 2002 draft. Fish Program, Science Division. Washington Department of Fish and Wildlife. Olympia, Washington. 43p.

Young, S.F. and J.B. Shaklee. 2000. Genetic interrelationships of selected chinook salmon populations in Lake Washington/Lake Sammamish basin based on microsatellite DNA variation. Fish Program, Genetics Laboratory. Washington Department of Fish and Wildlife. Olympia, WA. 13p.